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To: Mr. B.R. Churchill
Manager of Engineering
Bruce NGS
Generation Projects

Attn: Mr. M.S. Ho

BRUCE NGS 'B' UNIT 7
TURBO-GENERATOR STABILITY INSTRUMENTATION PROGRAM

A.G. Morton

This report presents the results of an on-going program for monitoring turbo-generator stability at Bruce NGS 'B' Units 5 to 8. Information obtained from this study indicates the magnitude and direction of movements of the structural components supporting the turbo-generator table. The change of turbine table profile, spring support spans, and support column elevations are discussed. This record of initial operating conditions may be of great value in the future during maintenance procedures or run-up programs. Reference readings for Unit 8 will be presented as it comes on line.

INTRODUCTION

This report presents the results of an on-going program to monitor the turbo-generator stability of the Bruce NGS 'B' Unit No 7. The measured change of vertical profile of the turbine table operating at 850 MW loading conditions relative to the static operating profile is discussed. Also, horizontal deflections of the turbine table, vertical changes across the Stadelman spring support system, and vertical changes in the turbine table support columns were monitored. Civil Research Department Report No 84-153-K/1/ details the description and location of all the instruments and hardware installed to facilitate the measurements mentioned above. Datum readings for all the measurement stations are also included in the above report.

The data included in this report is interpreted in three ways, where possible. They are as follows:

1. reference measurements to static operating condition,
2. static operating to dynamic operating load, and
3. reference measurements to dynamic operating load - where reference readings were taken at near 100% of the static operating load.

job	file	date	report no.
43-099-807	843.12 Bru	March 15, 1988	88-60-K

89-02567/

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The reference readings were measured in March, 1985 with the turbine table near 100% loading. The full static operating profile was obtained on January 16, 1986. Measurements were taken April 8, 1986 when the unit was operating at 850 MW, for the dynamic operating profile. Reading changes from March 1985 to January 1986 represent the effects of adjustment to the Stadelman spring supports and vacuum tests. Changes observed from January to April 1986 result from vacuum, temperature increases and the dynamic rotation of the unit operating at 850 MW.

TURBINE TABLE DIFFERENTIAL MOVEMENT

The vertical profile changes measured on the combination (elevation and alignment) survey stations at the 639 level were interpreted relative to turbine table Station 13, on the southwest corner of the unit. Readings relative to Station 13 detail the contour of the table and indicate any tendencies toward tilting, twisting, or areas of excessive profile change. Figure 1 gives the location of the turbine table and sole plate stations. The data is presented in Table I and the total measured change from the static operating profile to the 850 MW dynamic operating condition is graphically presented in Figure 2. Generally, the ends of the unit have moved slightly upward or remained stationary. The centre of the unit has deflected down with load to a maximum of 0.228 cm (0.090 inches).

In addition to the above combination stations on the table concrete supplied by Civil Research, 12 elevation monitoring stations were installed on the sole plates adjacent to the main bearing locations by construction forces. Elevation changes measured on these stations showed identical trends to the combination stations located on the support table surface (Table VI and Figure 2). These findings indicate that the turbine table concrete and the sole plate act as a single unit when considering vertical differential movements. The maximum downward deflection at full load measured on Unit 6 turbine table/2/ was 0.066 cm (0.026 inches) while Unit 5 displayed a much larger deflection of 0.255 cm (0.100 inches)/3/. This is in close agreement with the 0.228 cm (0.090 inches) measured on Unit 7.

The static operating profile, measured at the sole plate stations, is presented in Table VI and is shown graphically in Figure 7. A rapid change in the profile is noted between the generator and the LP portion of the unit.

Figure 2 illustrates the measured profile change of each side of the turbine table after machine support adjustments and run-up. This data is included in Table I. The illustrated profile change is the cumulative effect of Stadelman spring support adjustments (with removal of vertical stops) and vacuum forces applied during vacuum tests. Changes in column elevations could also be contributing to the profile change. Changes from the 850 MW dynamic operating profile relative to the reference profile are the influence of vacuum, temperature increase and rotational effects of the unit operating at 850 MW conditions.

TURBINE SUPPORT COLUMNS

Support column elevation changes from 850 MW conditions relative to the static operating elevations are presented in Table II and shown in Figure 3. The

general trend shows very little elevation change with some slight upward movement noted on the north side of the unit to a maximum of 0.085 cm (0.033 inches). Increases in elevation of column stations on these units were believed to have been caused by thermal expansion of the concrete columns located over the condenser pit. This explanation is questionable as elevation increases were noted on only one side of the unit in the case of Unit 7.

DIFFERENTIAL HORIZONTAL MOVEMENTS

Static operating and dynamic operating alignment are summarized in Table III. The amount of horizontal deflection was minimal averaging only 0.020 inches with a maximum movement of 0.037 inches measured. Most measurements indicated movement to the north relative to the reference stations at the ends of the turbine table. The centre of the turbine table is bending north relative to the ends of the turbine table.

EXTENSOMETER - STADELMAN SPRING SUPPORT GAP STATIONS

Datum extensometer readings were taken across the spring support spans on March 19, 1985 with the unit at the full static load condition. A second set, the static operating measurements, after spring adjustments, were taken on January 16, 1986. The dynamic operating measurements at 850 MW were taken on April 10, 1986. The data is listed in Table IV and is shown graphically in Figure 4. The reference to static operating profile is a measure of the changes occurring due to spring adjustments during vacuum tests. The dynamic operating profile illustrates the change due to operation of the unit at 850 MW relative to the static operating measurements. The dynamic operating profile shows some slight increase in gap space at the extreme west end of the unit (generator end). All other gap stations show a decrease in span with a maximum reduction of 0.149 cm (0.059 inches) occurring near the centre of the unit. At the HP end of the unit, almost no gap change was detected. The changes in gap distance at the spring supports match quite closely the table elevation changes noted earlier (see Figure 5). These trends are very similar to the findings of the work carried out on Unit 5 /3/. Rotational effects and temperature change account for the changes shown in the dynamic operating conditions.

PLUMB LINE MEASUREMENTS

Details of the plumb lines construction and datum readings are included in Civil Research Department Report No 84-153-K. The four plumb lines are located on the columns at the four extreme corners of the turbine support table. The plumb lines measure the movement of the machine support table in two horizontal directions with respect to the base of the pier columns. Readings taken under dynamic operating conditions are included in Table V. The movements observed at the plumb lines were very small. A graphical presentation (Figure 6) indicates slight horizontal movement of the table towards the north, combined with a slight movement towards the centre in the longitudinal direction. This slight inward trend may be due to the downward bending of the table shown in Figure 2 with the unit operating at 850 MW. This bowing action of the turbine table concrete was also noted on Unit 5 and would tend to draw the corners of the support table slightly closer towards the centre.

FOUNDATION VIBRATION MEASUREMENTS

Turbo-generator foundation vibration measurements were carried out on Unit 7 by the Mechanical Research Department. The unit was operating at 887 MW at the time of the testing. See attached Appendix A for detailed information and results.

SUMMARY

From the static operating profile to the 850 MW dynamic profile a maximum downward deflection of 0.228cm was measured in the centre of the turbine table relative to the datum station at one end of the unit. Construction installed sole plate stations indicate similar turbine table deflection trends.

The maximum deflection of 0.228 cm measured on the dynamic profile was similar to the 0.255 cm measured on Unit 5 but is several times larger than the Unit 6 maximum deflection of 0.066 cm at 850 MW conditions/2/.

Turbine support columns showed generally no elevation change with a slight increase in elevation noted over the condenser pit on the south side of the unit. A maximum of 0.085 cm change was measured.

Horizontal deflection stations show minute bending of the centre of the unit in a northerly direction relative to the reference stations at both ends of the turbine table.

Spring support gap measurements show decreases in gap distance in the middle of the unit at 850 MW conditions relative to the static operating condition. The ends of the unit show no change or a minimal increase at 850 MW. These changes are similar to those measured at the turbine table stations.

Plumb line station measurements at 850 MW operating conditions show a slight northward movement of the turbine table as well as a slight movement toward the centre of the unit in the longitudinal direction. This is toward the centre of the unit in the longitudinal direction. This is possibly due to downward bending of the turbine table indicated by the turbine table and sole plate stations.

Approved by:

T.W. Klym
Manager
Civil Research Department

Prepared by:

A.G. Morton
Technician
Soil Sciences Section

Reviewed by:

C.B.H. Cragg
Senior Engineer
Soil Sciences Section

AGM:LM

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REFERENCES

1. A.G. Morton. "Instrumentation Report - Bruce GS 'B' Turbo-Generators 5 to 8 - Stability Instrumentation Program". Research Division Report No 84-153-K. July 11, 1984.

2. A.G. Morton. "Bruce NGS 'B' Unit 6 - Turbo-Generator Stability Instrumentation Program". Research Division Report No 85-74-K. March 25, 1985.

3. A.G. Morton. "Bruce NGS 'B' Unit 5 - Turbo-Generator Stability Instrumentation Program". Research Division Report No 85-197-K, October 10, 1985.

TABLE I

Bruce NGS 'B' Unit 7
Turbine Table Elevation Chainages 639' Elevation

Station	Reference Profile March 19/85	Station Operating Profile Jan 16/86	Dynamic Operating Profile April 8/86	Change March 19/85 - Jan 16/86	Jan 16/86 - April 8/86	Change March 19/85 - April 8/86
13	0.000	0.000	0.000	0	0	0
14	0.808	0.759	0.655	-0.049	-0.104	-0.153
15	0.815	0.785	0.627	-0.030	-0.158	-0.188
16	1.425	1.400	1.237	-0.025	-0.163	-0.188
17	-0.376	-0.396	-0.495	-0.020	-0.099	-0.119
18	1.641	1.648	1.717	+0.007	+0.069	+0.076
19	1.709	1.709	1.750	0.000	+0.041	+0.041
20	1.085	1.046	0.940	-0.039	-0.106	-0.145
21	0.500	0.472	0.244	-0.028	-0.228	-0.256
22	0.203	0.178	0.033	-0.025	-0.145	-0.170
23	0.155	0.155	0.015	0.000	-0.140	-0.140
24	0.163	0.180	0.145	+0.017	-0.035	-0.018

TABLE II

Bruce NGS 'B' Unit No 7
Support Column Elevation Changes 591' Elevation

Station	Operating Profile Feb 28/85 (cm)	Operating Profile April 9/86 (cm)	Change (cm)
1	0.000	0.000	0.0
2	-0.351	-0.371	-0.020
3	-0.727	-0.757	-0.030
4	-0.648	-0.643	+0.005
5	-0.659	-0.629	-0.030
6	-0.345	-0.535	OBSTRUCTION
7	-0.036	-0.006	+0.030
8	-0.646	-0.596	+0.050
9	-0.457	-0.417	+0.040
10	-0.893	-0.808	+0.085
11	-0.554	-0.544	+0.010
12	-0.020	0.000	+0.020

TABLE III

Bruce NGS 'B' Unit No 7
Differential Horizontal Movements
639' Level

Station	Static Operating Profile March 26/85	Dynamic Operating Profile April 9/86	Change (inches)
13	Instrument Station	Instrument Station	
14	3.330	3.273	0.027 South
15	3.176	3.201	0.026 North
16	3.290	3.290	0.000
17	3.167	3.146	0.023 South
18	3.280 Chk Station	Chk Stn readings obstructed due to heat waves	
19	Chk Station 3.295		
20	3.231	3.253	0.022 North
21	3.345	3.363	0.018 North
22	3.336	3.373	0.037 North
23	3.393	4.004	0.011 North
24	Instrument Station	Instrument Station	

NOTE: Future readings higher than datum will indicate a reading station shift to the north

TABLE IV

Bruce NGS 'B' Unit No 7
Spring Support Gap Measurements

Gap Station No	Reference Profile March 19/85 (cm)	Operating Profile Jan 16/86 (cm)	Operating Profile April 10/86 (cm)	Change March 19/85 - Jan 16/86	Change Jan 16/86 - April 10/86
G-1	61.000	61.083	61.094	+0.083	+0.011
G-2	61.015	60.972	60.869	-0.043	-0.103
G-3	61.003	60.936	60.798	-0.067	-0.138
G-4	61.075	61.025	60.897	-0.050	-0.128
G-5	60.975	60.940	60.908	-0.035	-0.032
G-6	71.220	71.210	71.253	-0.010	+0.043
G-7	71.318	71.298	71.337	-0.020	+0.039
G-8	61.160	61.138	61.052	-0.022	-0.086
G-9	61.170	61.148	60.999	-0.022	-0.149
G-10	61.075	61.036	60.899	-0.039	-0.137
G-11	61.092	61.070	60.970	-0.022	-0.100
G12	61.118	61.111	61.117	-0.007	+0.006

TABLE V

Bruce NGS 'B' Unit No 7
Plumb Line Measurements

Measuring Station No	Average Reading North		Change (mm)	Average Reading South		Change (mm)
	Feb 25/85	April 10/86		Feb 25/85	April 10/86	
PL1	12.03	12.58	-0.55	13.83	12.96	0.87
PL2	12.85	15.15	-2.30	13.10	10.76	2.35
PL3	11.82	12.50	-0.68	14.13	13.24	0.89
PL4	12.12	12.43	-0.31	13.79	13.32	0.47

Measuring Station No	Average Reading East		Change (mm)	Average Reading West		Change (mm)
	Feb 25/85	April 10/86		Feb 25/85	April 10/86	
PL1	10.90	14.85	-3.95	14.95	10.87	4.08
PL2	9.62	9.63	-0.01	16.15	16.01	0.14
PL3	10.24	9.69	0.55	15.36	15.68	-0.32
PL4	12.63	16.32	-3.69	13.08	9.43	3.65

TABLE VI

Sole Plate Station No	Full Static Load Profile Jan 16/86 (cm)	Dynamic Operating Profile April 8/86 (cm)	Change (cm)
B-1	2.131	2.121	-0.010
B-2	1.704	1.613	-0.091
B-3	1.585	1.463	-0.122
B-4	1.560	1.394	-0.166
B-5	1.565	1.387	-0.178
B-6	1.562	1.516	-0.046
B-7	1.613	1.514	-0.099
B-8	1.575	1.336	-0.239
B-9	1.534	1.315	-0.219
B-10	1.588	1.468	-0.120
B-11	1.814	1.709	-0.105
B-12	2.029	2.007	-0.022

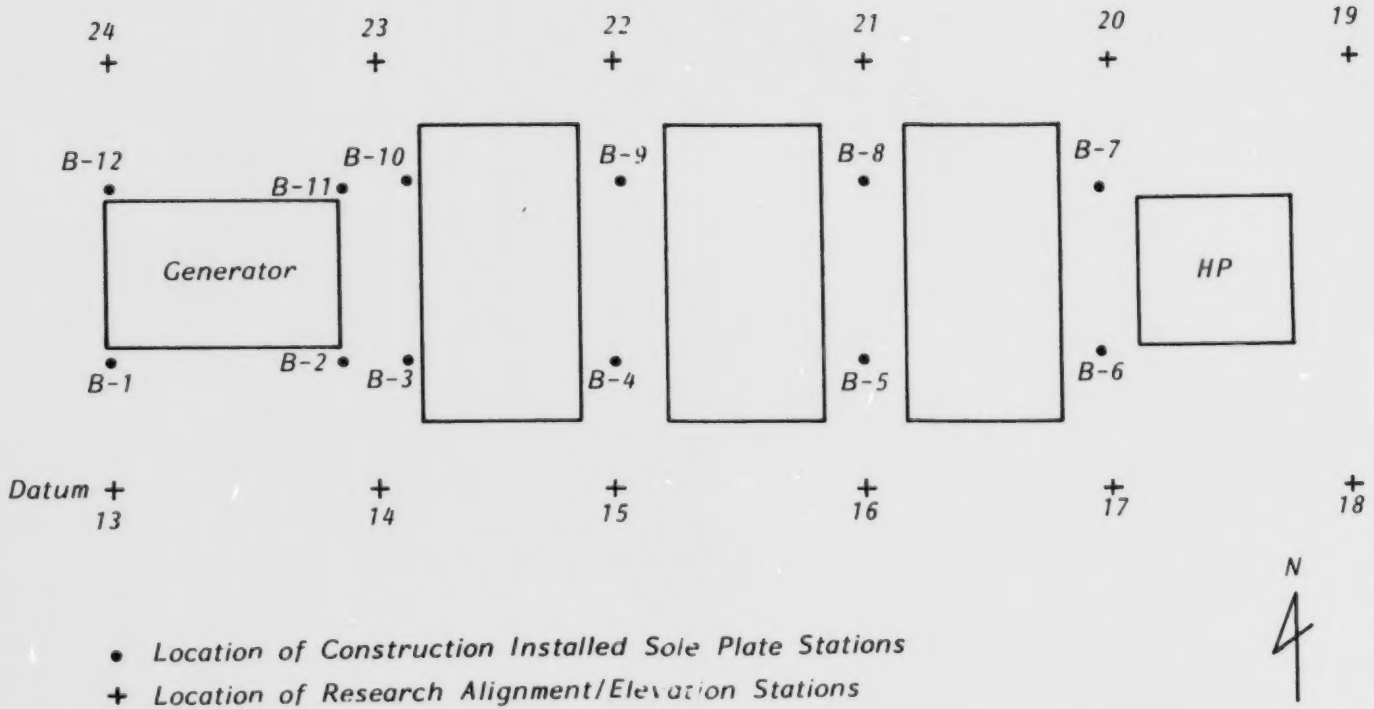


FIGURE 1

BRUCE NGS 'B' UNIT NO 7
SURVEY PIN LOCATIONS/SOLE PLATE STATIONS

88-60
176661-RD

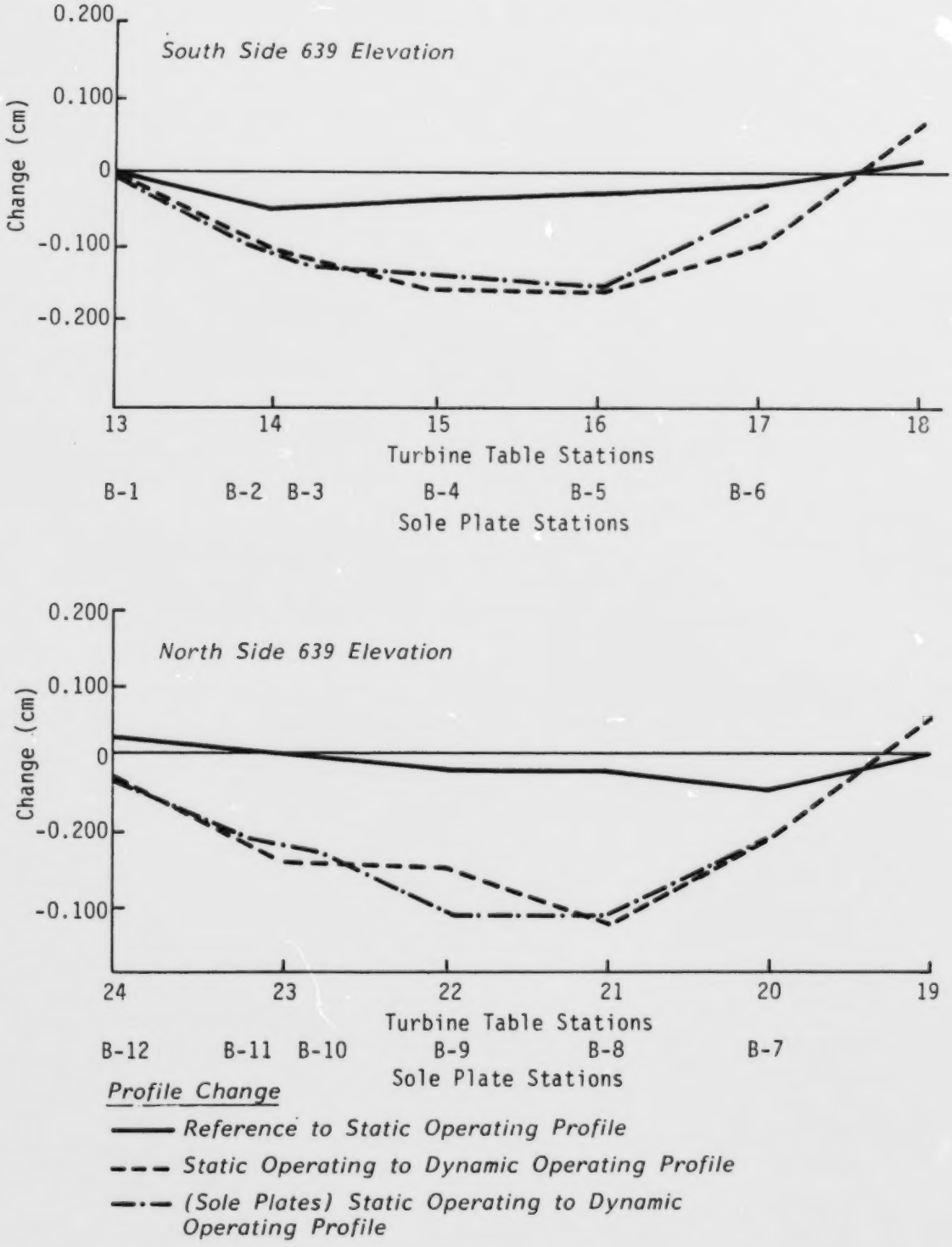
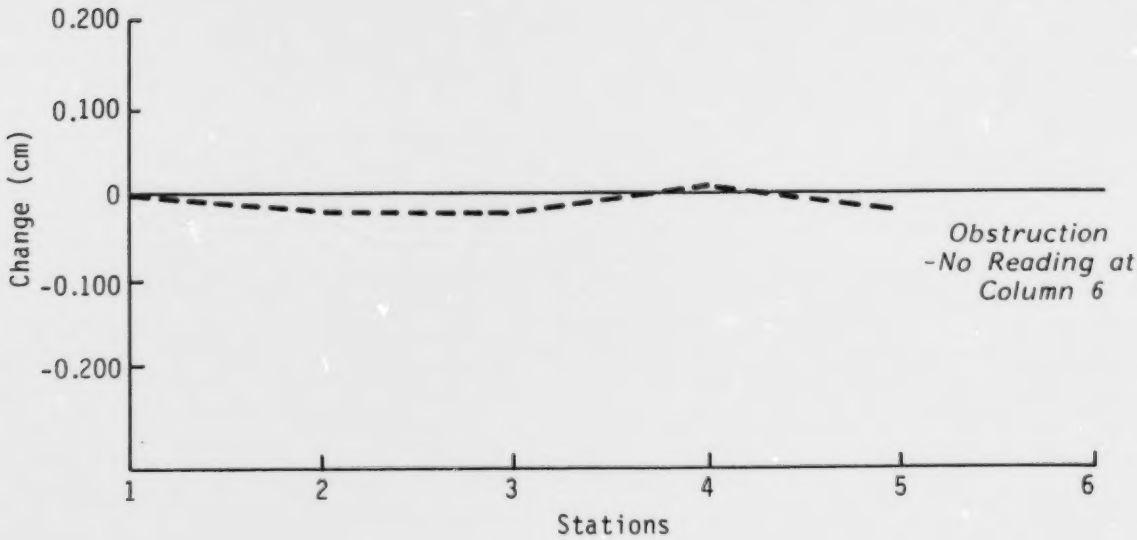


FIGURE 2

BRUCE NGS 'B' UNIT NO 7
TURBINE TABLE PROFILE CHANGES



BRUCE NGS 'B' UNIT NO 7
TURBINE SUPPORT COLUMN PROFILE CHANGES
SOUTH SIDE 593'6 ELEV

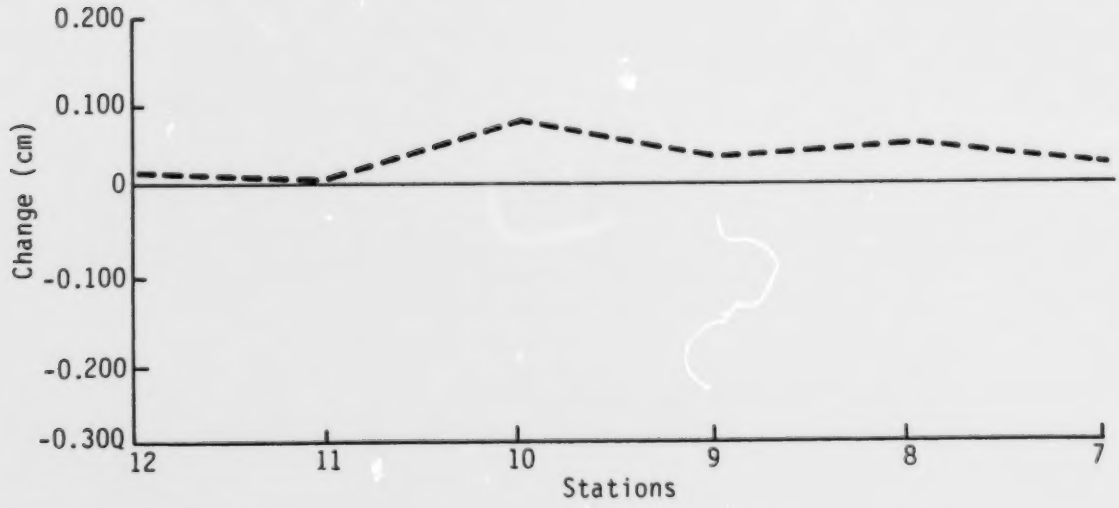


FIGURE 3
BRUCE NGS 'B' UNIT NO 7
TURBINE SUPPORT COLUMN PROFILE CHANGES
NORTH SIDE 593'6 ELEV

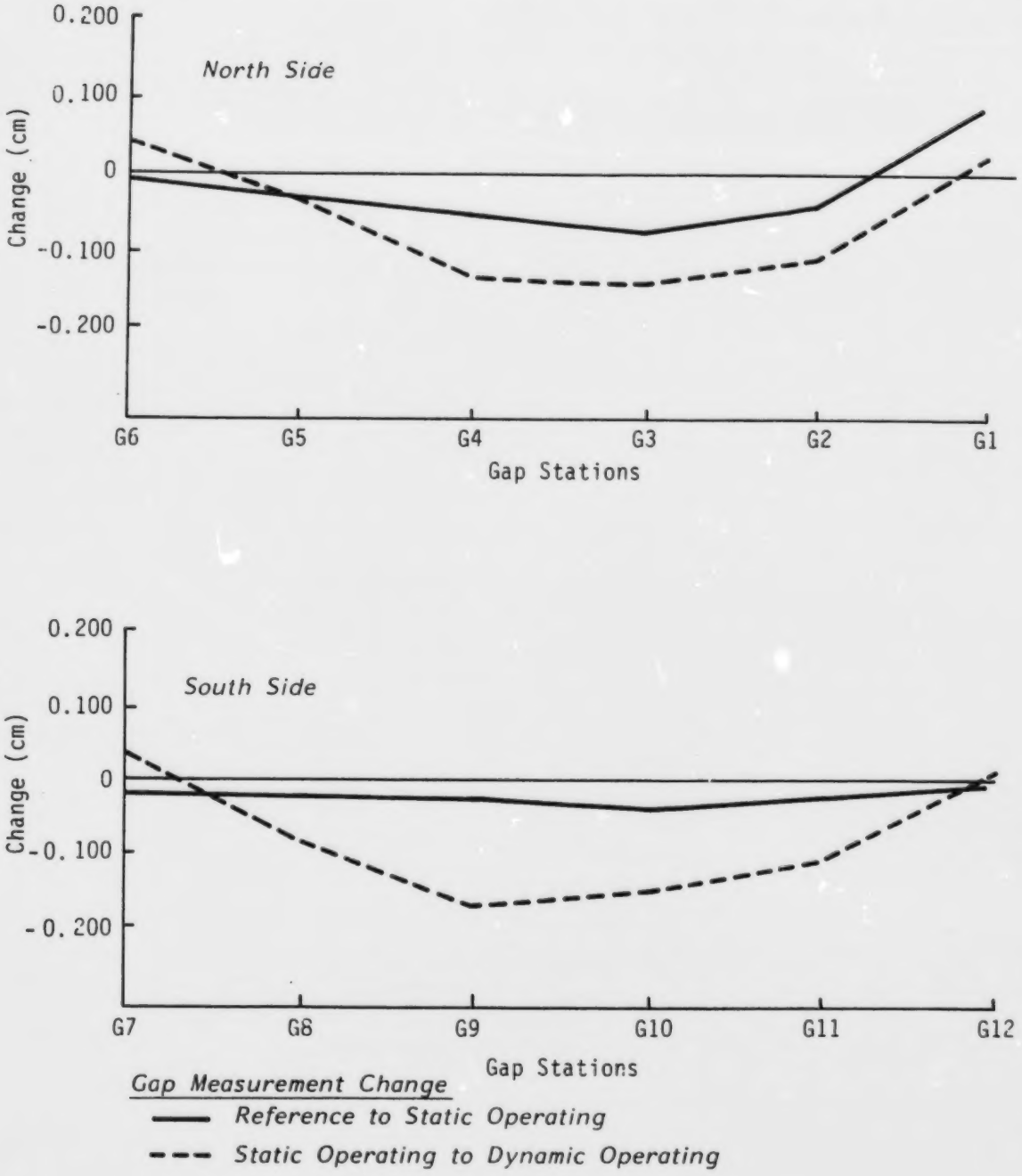


FIGURE 4

BRUCE NGS 'B' UNIT NO 7
SPRING SUPPORT GAP MEASUREMENTS

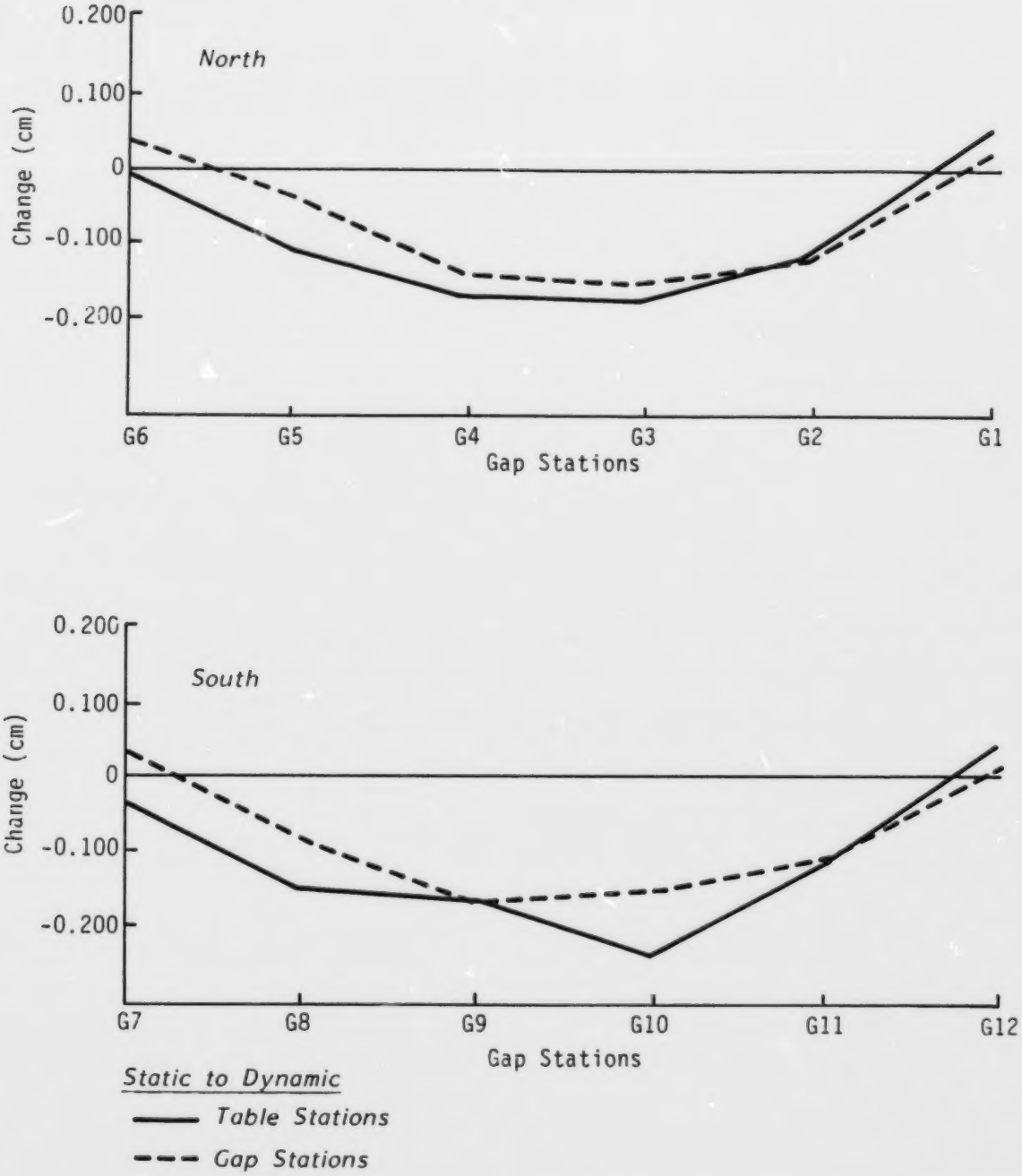


FIGURE 5

BRUCE NGS 'B' UNIT NO 7
SPRING SUPPORT GAP CHANGES VS
TURBINE TABLE PROFILE CHANGES

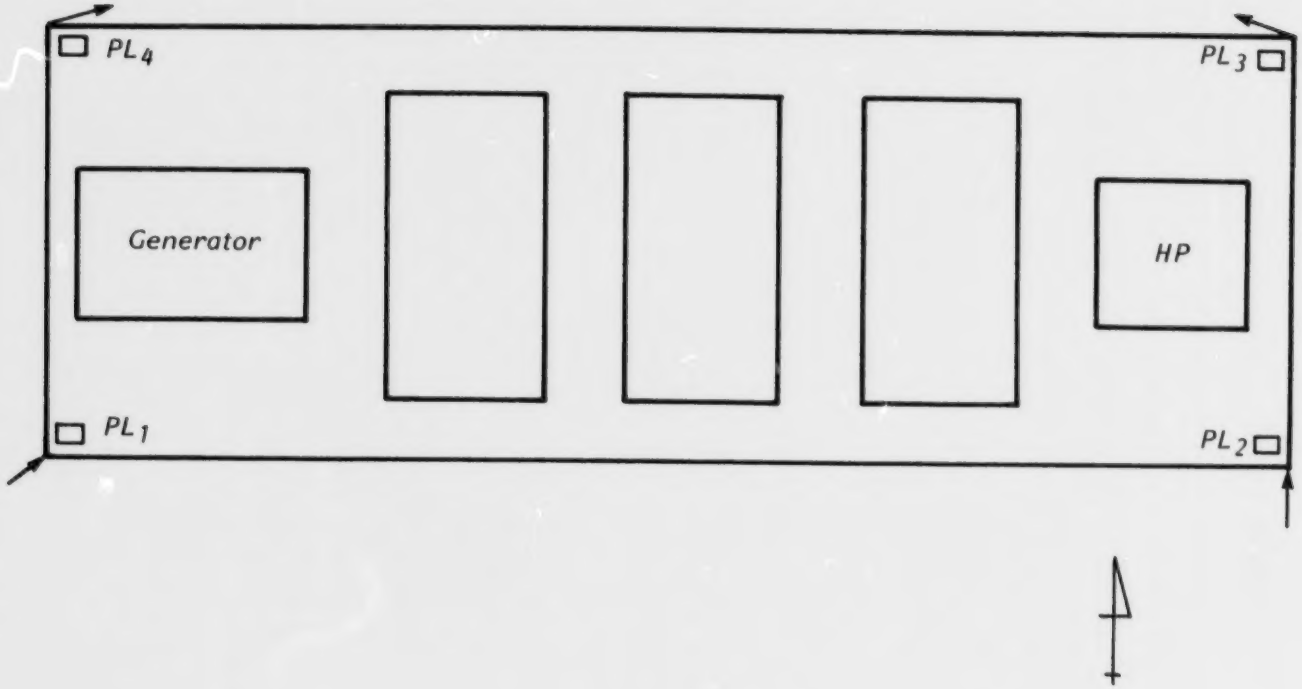
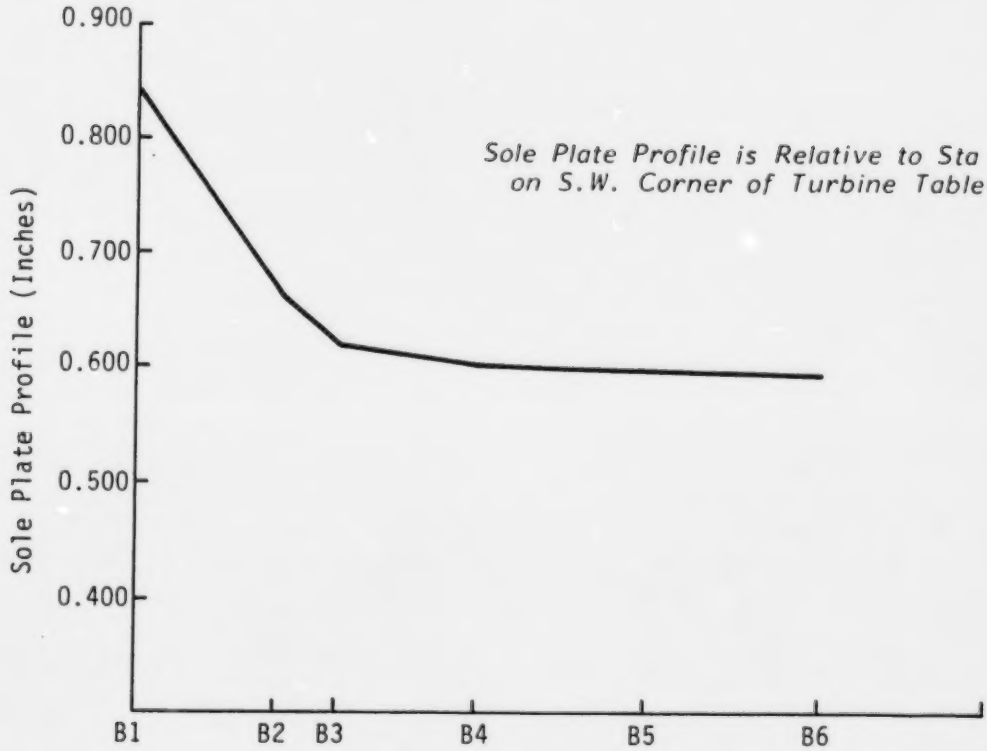


FIGURE 6

BRUCE NGS 'B' UNIT 7
PLUMB LINE INDICATIONS



BRUCE NGS 'B' UNIT NO 8
SOLE PLATE PROFILE - SOUTH SIDE

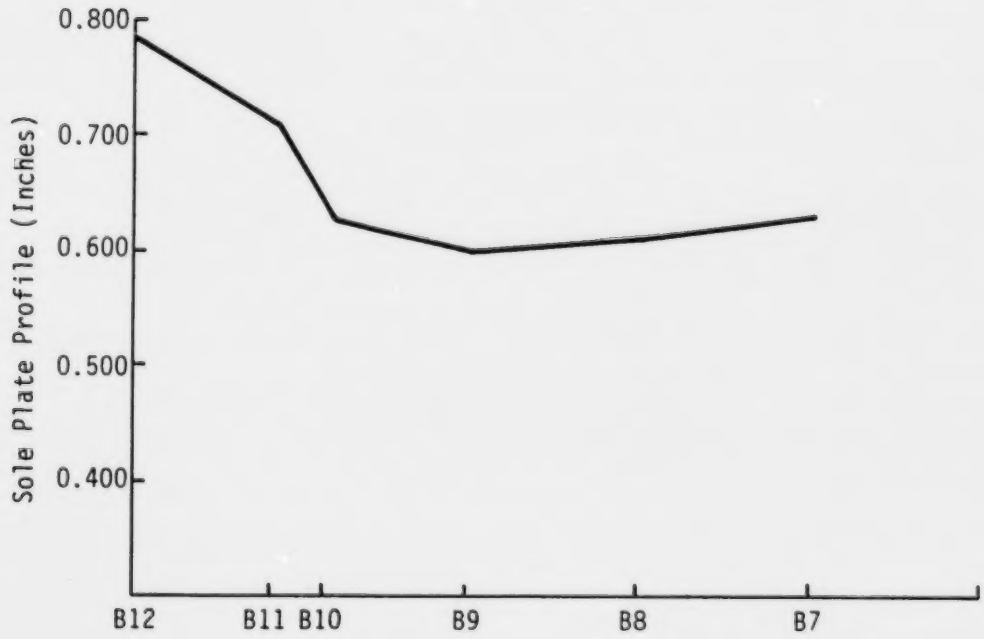


FIGURE 7

BRUCE NGS 'B' UNIT NO 7
SOLE PLATE PROFILE - NORTH SIDE

APPENDIX A

Mr. C.B. Cragg

ontario hydro
research division

To
Mr. T.J. Carmichael
Supervising Design Engineer - Soils
Civil Research Department

BRUCE NGS 'B' - UNIT 7 - TURBO-GENERATOR
FOUNDATION VIBRATION MEASUREMENTS

1.0 INTRODUCTION

At the request of the Civil Research Department, vibration measurements were taken on the turbo-generator foundation of Unit 7 while at full load (887 MW).

2.0 TEST INSTRUMENTATION

A list of the instrumentation used for the measurements is given in Appendix A.

3.0 MEASUREMENTS

Twelve measurements of vertical vibration were taken at the settlement stations defined in Figure 1. Of the two accelerometers used, one remained at S13 while the other was systematically moved to obtain measurements at the other stations. The accelerometers were held in place by flanged studs cemented to the metal cover plate at each settlement station. All measurements were of vibration velocity.

For tape recording, the charge amplifiers were set to a lower limiting frequency of 1 Hz and an upper limiting frequency of 3 kHz.

The recordings were taken on a Hewlett Packard tape recorder at a tape speed of 7.5 in/s. The settlement stations allocated to each channel are listed in Table I. The tape is designated "Bruce 'B', Unit 7, Turbo-generator Foundation Measurements, June 24/86".

Vibration velocity spectra were produced in real time using a Nicolet dual channel FFT analyzer. Overall vibration velocity levels were measured by a Bently Nevada DVF2 digital vector filter. For the spectra and overall velocity levels, the charge amplifier frequency settings were 1 Hz and 1 kHz.

4.0 TEST RESULTS

The overall velocity levels listed in Table I are all below 1.3 mm/s (0.05 in/s).

Spectra of vibration velocity (averages of 16 spectra) for each settlement station are given in Figures 2 to 13. The spectra are dominated chiefly by the 30 Hz (1 x rpm) forcing frequency and a number of structural natural frequencies, of which the greatest four are 8, 11, 13.5 and 16.5 Hz.

Figures 14 to 18 show the foundation displacements and velocities at frequencies of 8, 11, 13.5, 16.5 and 30 Hz. The data for these figures were obtained from spectra taken from tape recordings.

Examination of the figures shows that at 11 Hz the mode is torsional; at 8 and 13.5 Hz the modes are bending; and at 16.5 and 30 Hz they are more complex having the elements of bending and torsion.

Figure 19 shows a foundation displacement mode shape constructed from spectral measurements at the frequencies of 8, 11, 13.5, 16.5 and 30 Hz.

Approved:

T. Loewen
Supervising Engineer
Plant Equipment Dynamics
Mechanical Research Department

Submitted:

R.B. Jay
Unit Head - Machine Dynamics
Plant Equipment Dynamics Section

W.D. Morgan
Technologist
Plant Equipment Dynamics Section
Mechanical Research Department

RBJ:is

TABLE I

BRUCE NGS 'B' - UNIT 7
TURBO-GENERATOR FOUNDATION VIBRATION

19.05 cm/s

Station No	T.R. Ch#	Tape Turns	Gain MV/ Unit Out	DVF II Velocity mm/s peak	Fig Nos of Frequency Spectra	
S-13	1	100	1000	0.50-0.80	2	REFERENCE
S-14	2	1110-1190	1000	0.20-0.50	3	
S-15	2	1025-1110	1000	0.50-0.70	4	
S-16	2	945-1025	1000	0.40-0.70	5	
S-17	2	845- 945	316	0.80-1.10	6	
S-18	2	745- 845	316	1.00-1.30	7	
S-19	2	655-745	316	0.90-1.20	8	
S-20	2	560-655	1000	0.80-1.00	9	
S-21	2	460-560	1000	0.50-0.70	10	
S-22	2	350-460	1000	0.30-0.50	11	
S-23	2	240-350	1000	0.80-1.00	12	
S-24	2	-240	316	1.00-1.20	13	

LLF = 1 Hz

ULF = 3 kHz (Recording)

1 kHz (DVF II Readings)

Pickup glued to top of station cap

TR CH# = Accel #

TAPE: BRUCE 'B', UNIT 7, TURBO-GENERATOR
FOUNDATION MEASUREMENTS, JUNE 24/86

BRUCE NGS B - UNIT 5

TURBO-GENERATOR FOUNDATION SETTLEMENT STATIONS AT ELEVATION 639

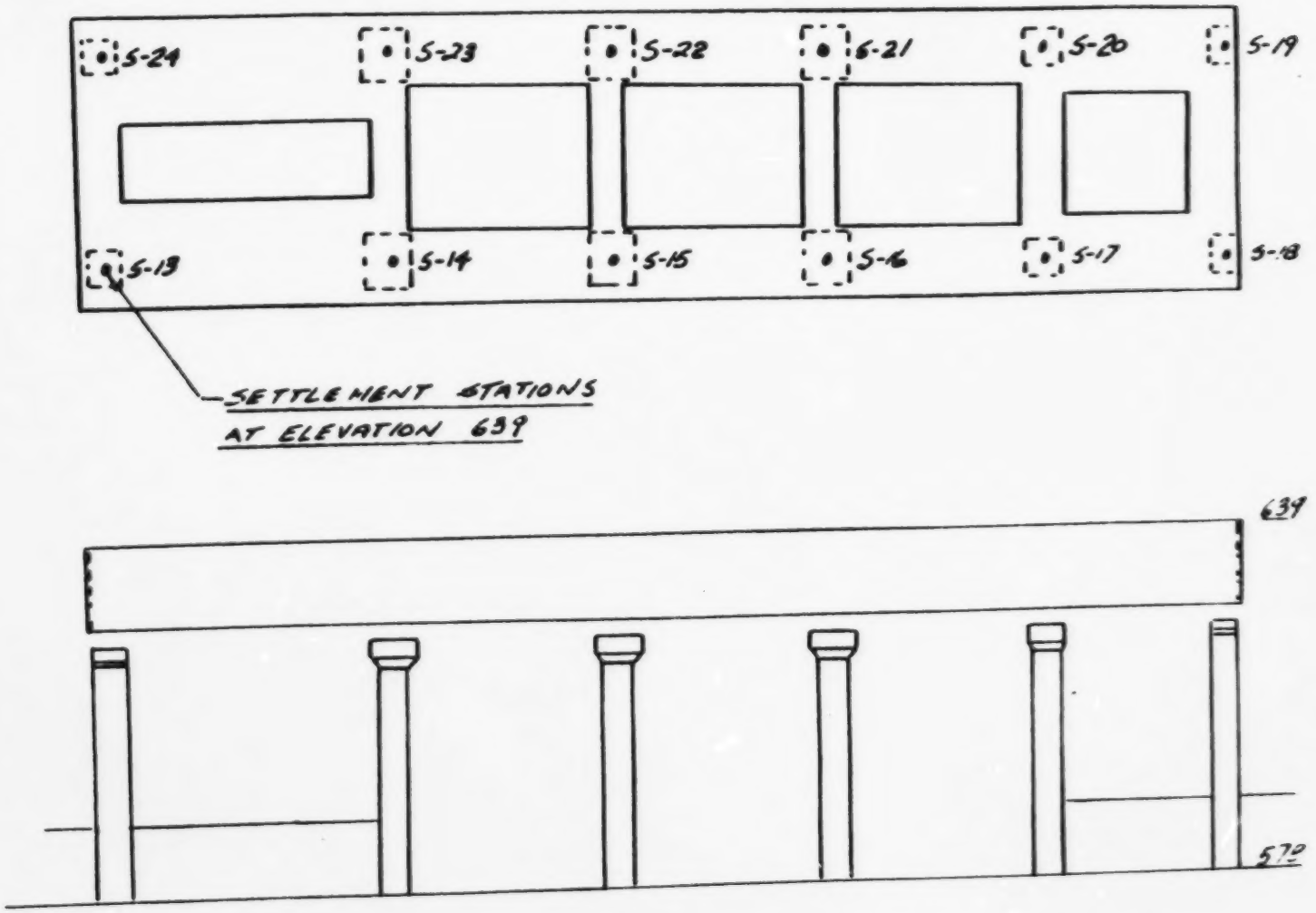


FIGURE 1

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#13

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.24
2	13	.1217
3	16	.1016
4	11	.00204
5	60	.07533
6	120	.05856
7	8	.04746
8	92	.04407
9	22.5	.03486
10	25.5	.03133
11	36.5	.02869
12	.5	.01685
13	64.5	.0162
14	90.5	.01317
15	45	.01054
16	48	.01034
17	41	.01017
18	47	.01008
19	67.5	8.058E-03
20	66	7.542E-03

70.7-03 V/EA 1.00+00 E VLG

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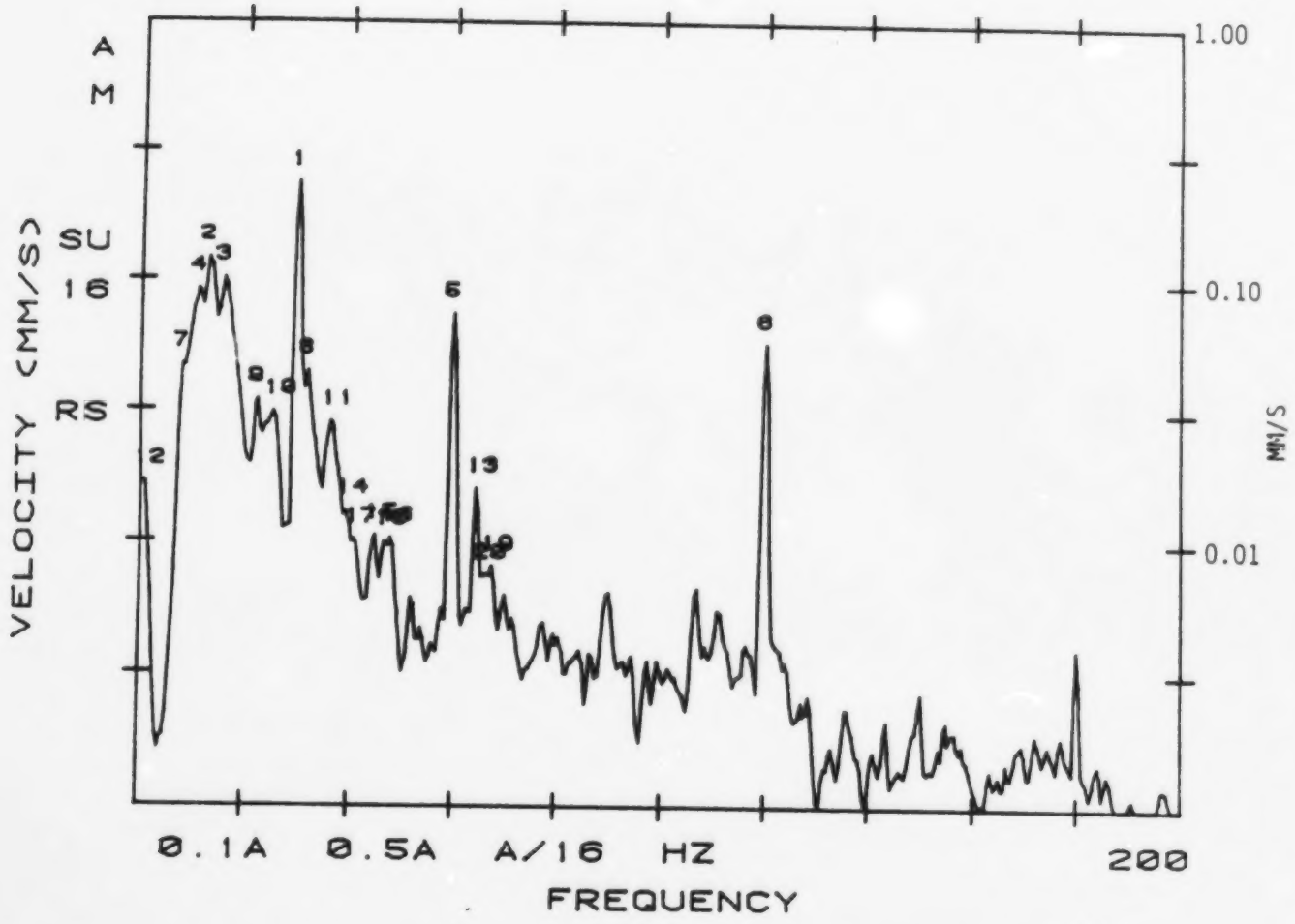


FIGURE 2

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#14

PEAK NO.	FREQUENCY	AMPLITUDE
1	14	.105
2	10.5	.00451
3	30	.00484
4	19	.0506
5	120	.03348
6	8	.0285
7	32.5	.02074
8	21	.02442
9	26	.02352
10	22.5	.02282
11	24	.02015
12	40.5	.01123
13	36	.01000
14	90	.01085
15	45	.01027
16	37.5	9.378E-03
17	48	9.378E-03
18	69.5	8.257000000E-03
19	60	6.498E-03
20	84.5	5.204E-03

70.7-03 V/EA 316.-03 E VLG

C

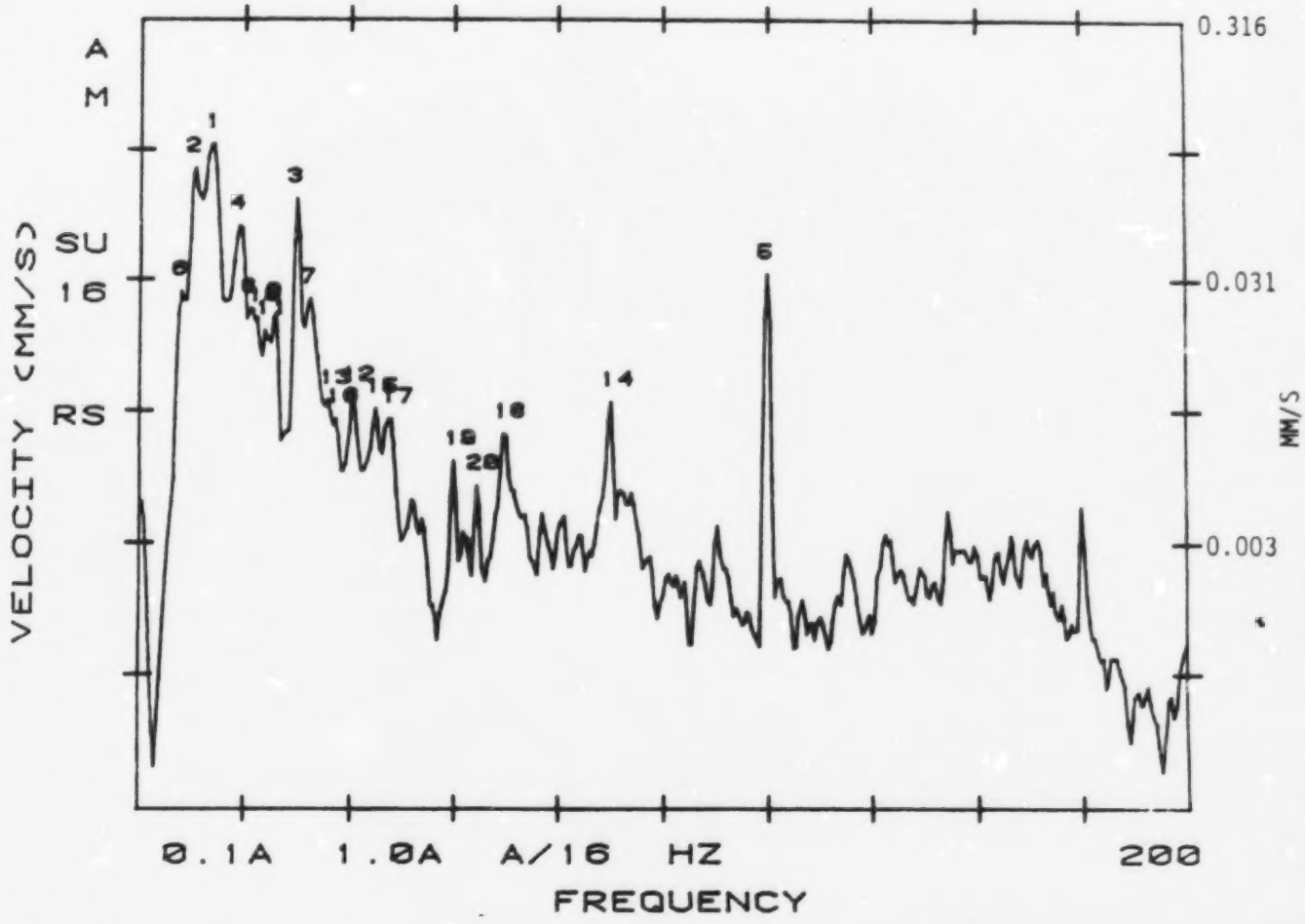


FIGURE 3

172320 E

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#15

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.3358
2	16.5	.1162
3	10	.106
4	13.5	.00016
5	32.5	.03716
6	22	.03578
7	21	.03276
8	60	.02387
9	24.5	.02234
10	36.5	.01708
11	38.5	.01627
12	48	.01614
13	120	.01380
14	45	9.82E-03
15	52.5	8.160E-03
16	.5	7.058E-03
17	70	6.543E-03
18	94	5.311E-03
19	110	5.160E-03
20	143.5	4.97E-03

70.7-03 V/EA 1.00+00 E VLG

C

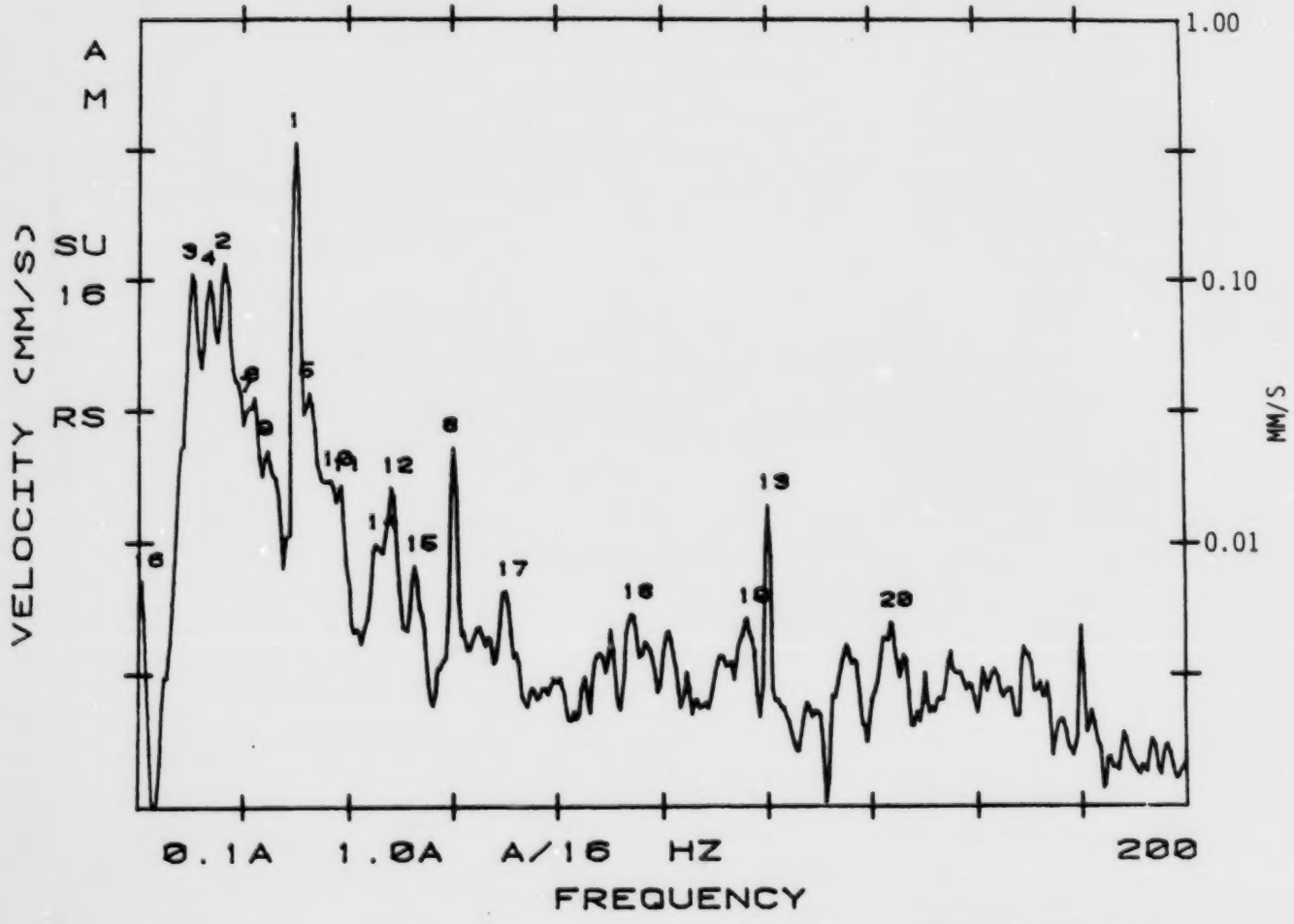


FIGURE 4

172321

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#16

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.2603
2	13.5	.1138
3	10	.00154
4	18	.07361
5	10	.04431
6	60	.0360
7	33	.0318
8	25.5	.02663
9	22.5	.02649
10	24.5	.02628
11	34.5	.01932
12	48	.01676
13	37	.01681
14	38.5	.01603
15	120	.01357
16	46.5	.01274
17	90	.0103
18	44.5	.01005
19	52	8.776E-03
20	54	7.512E-03

70.7-03 V/EA 1.00+00 E VLG

C

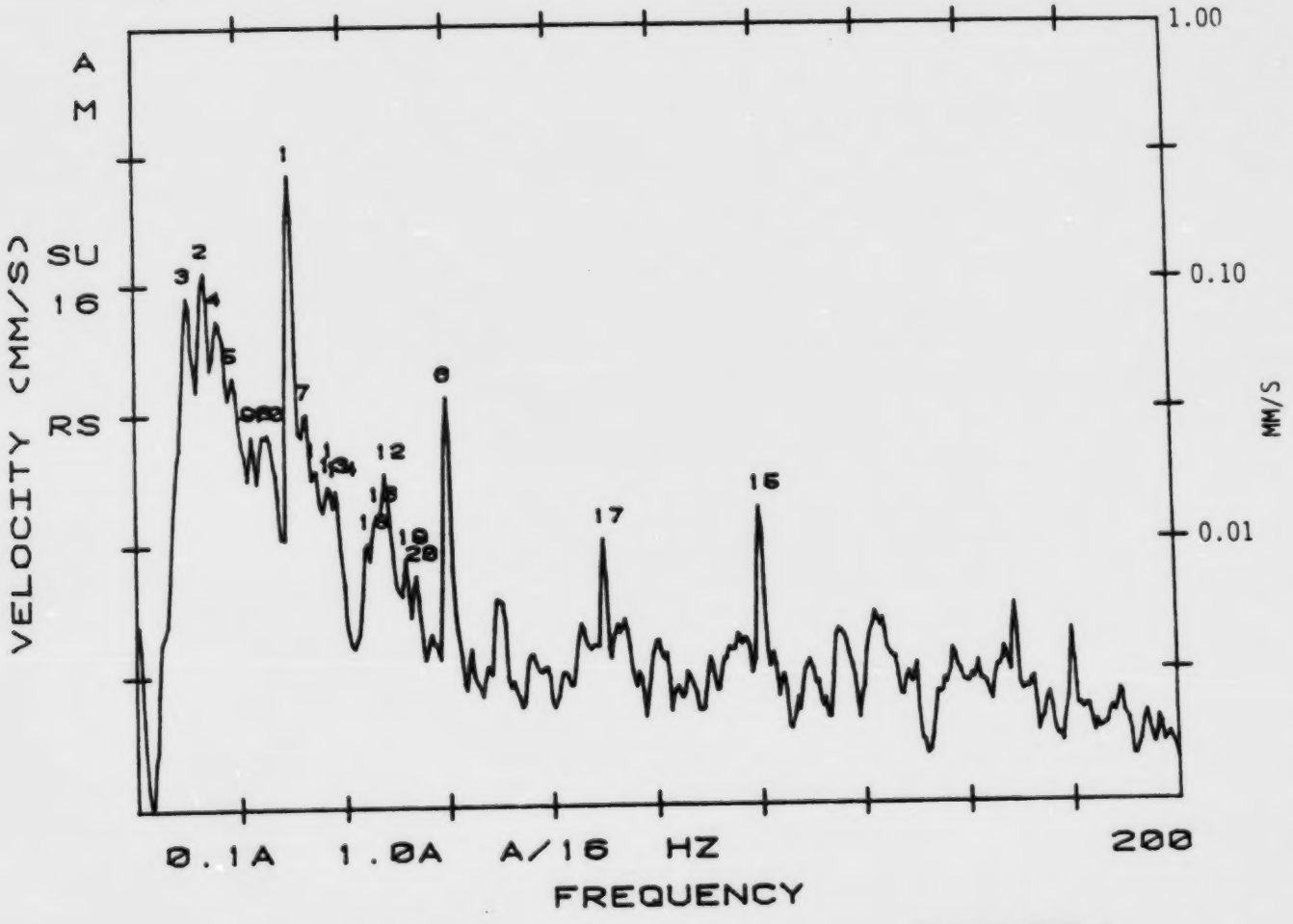


FIGURE 5

88-60

172322 F

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#17

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.6681
2	11	.0879
3	13	.07995
4	8	.07128
5	18.5	.0596
6	20.5	.03529
7	16	.02819
8	48	.02478
9	60	.02222
10	27	.01602
11	34.5	.01543
12	25.5	.01539
13	36	.01374
14	37	.01344
15	45.5	.01111
16	44	9.416E-03
17	52.5	7.832E-03
18	90	7.222E-03
19	.5	5.737E-03
20	60.5	5.000E-03

70.7-03 V/EA 1.00+00 E VLG

C

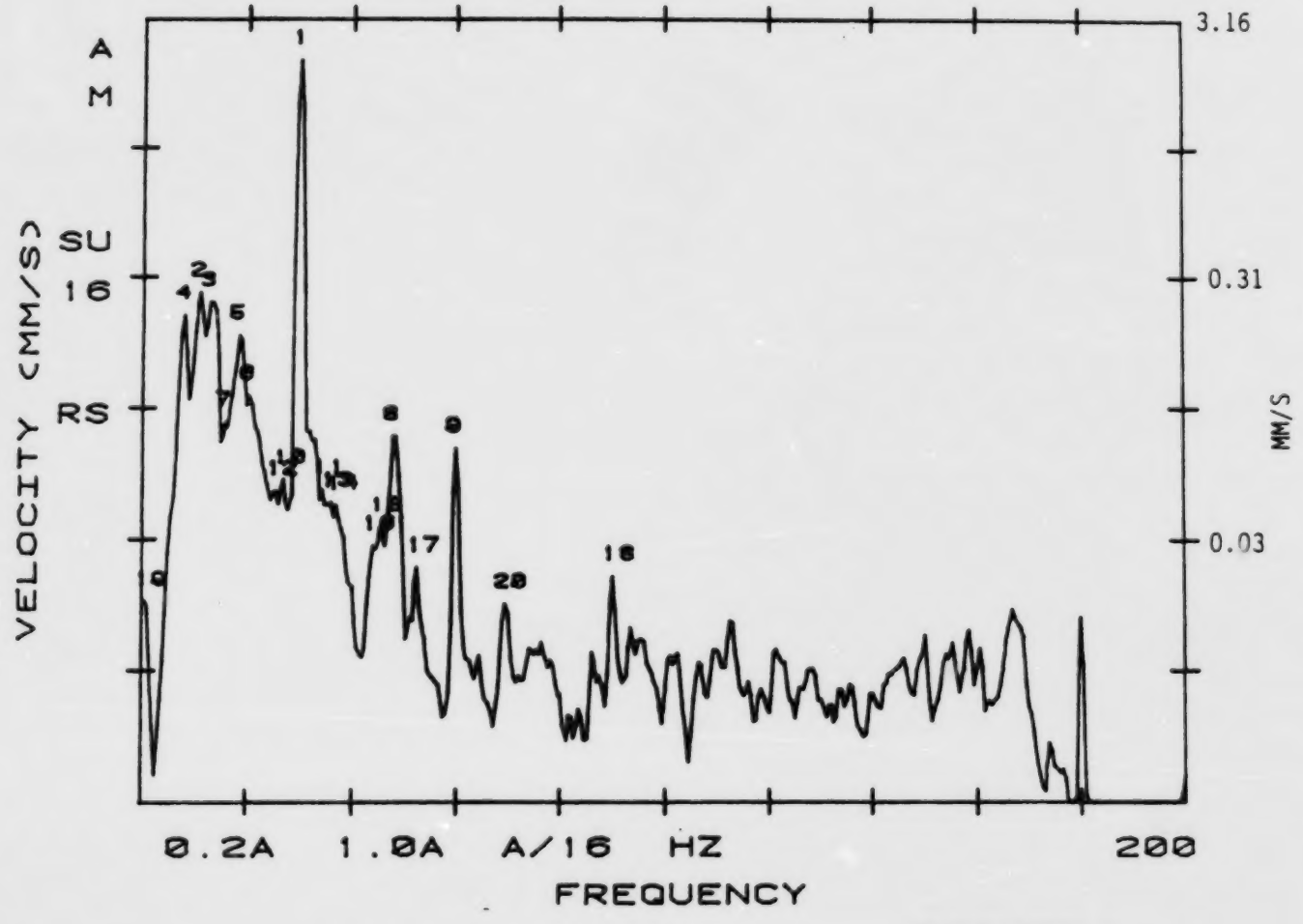


FIGURE 6

88-60

172323 R

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#18

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.7815
2	13	.1748
3	8	.1441
4	16.5	.08082
5	17.5	.06486
6	28	.05754
7	24.5	.04522
8	60	.04481
9	20.5	.04231
10	22.5	.04068
11	48.5	.03912
12	5.5	.03228
13	32	.0204
14	60.5	.01446
15	36	.01379
16	38.5	.01293
17	121	.01236
18	94	.01049
19	44	.01027
20	52.5	9.887E-03

70.7-03 V/EA 1.00+00 E VLG

C

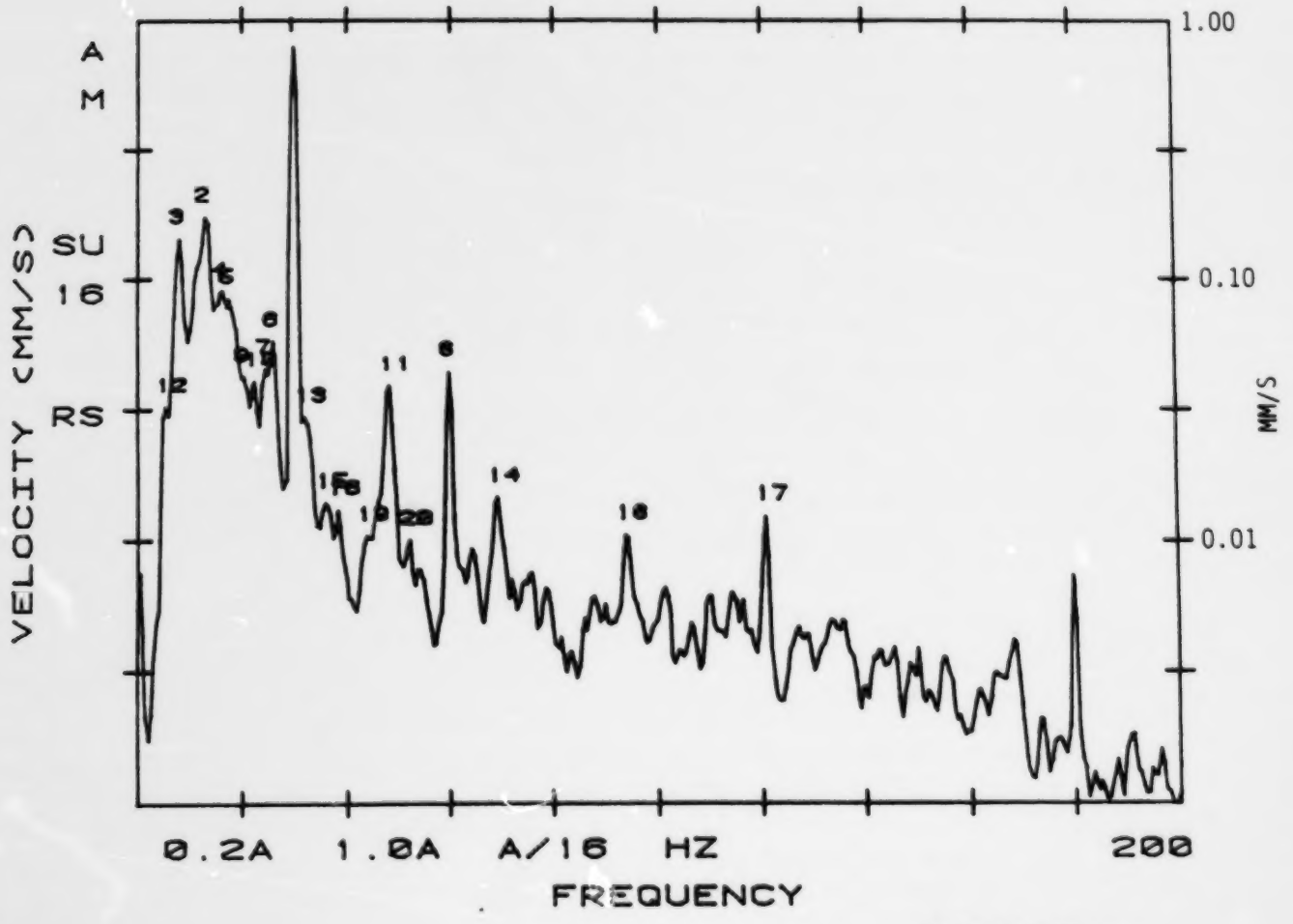


FIGURE 7

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#19

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.6396
2	13.5	.1727
3	11	.1387
4	8	.1357
5	18.5	.00664
6	26.5	.00613
7	16.5	.0617
8	60	.00116
9	22.5	.05026
10	21	.04485
11	.5	.03020
12	5	.02377
13	32	.02234
14	37.5	.01654
15	90	.01500
16	35	.01482
17	70	.01376
18	52	.0131
19	45	.01177
20	50	.01100

70.7-03 V/EA 1.00+00 E VLG

C

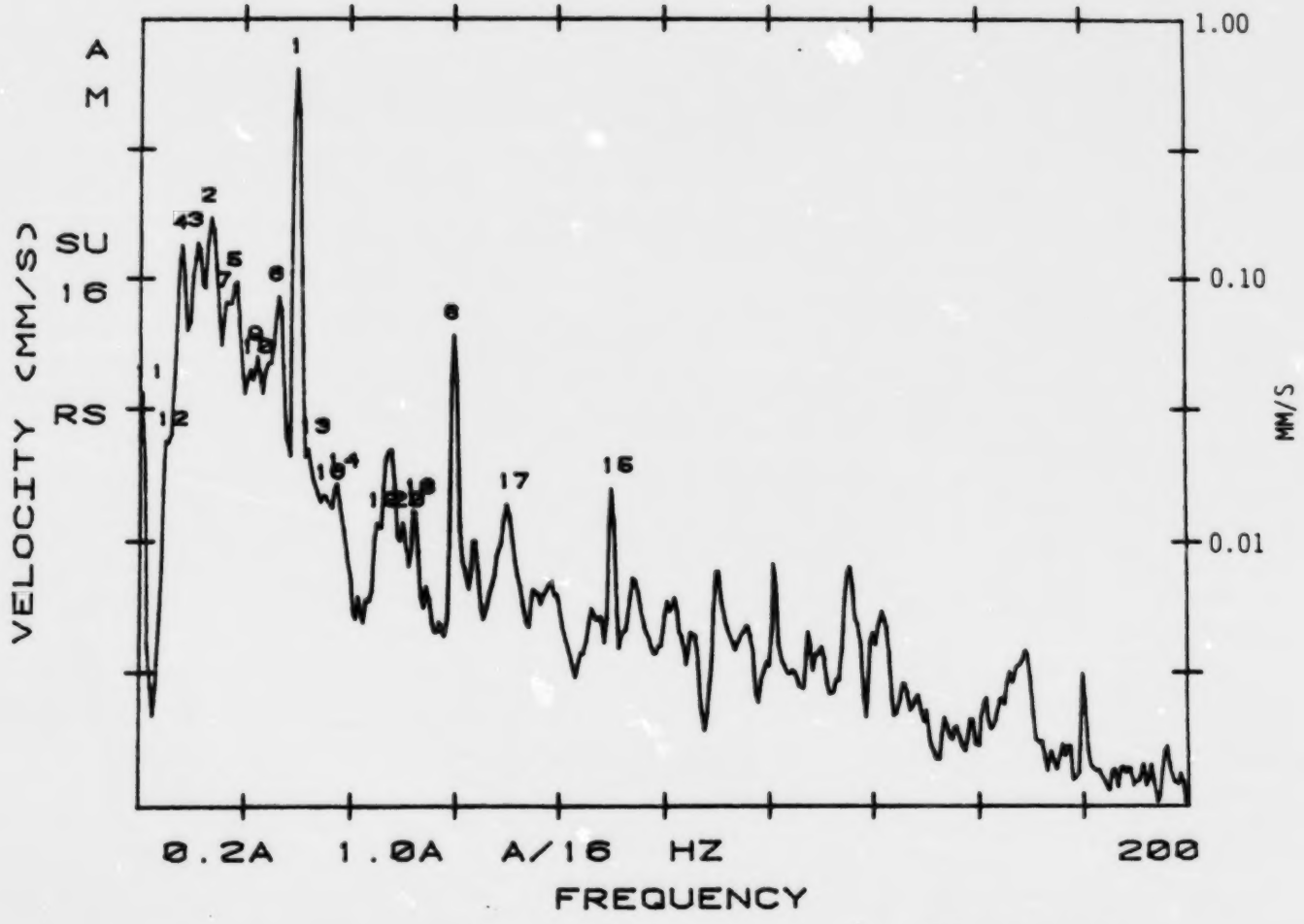


FIGURE 8
88-60

172325

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#20

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.7128
2	11	.08092
3	13	.07687
4	8	.06806
5	18.5	.06412
6	16.5	.03823
7	22	.0328
8	32.5	.02544
9	27	.01828
10	47	.01780
11	24.5	.01717
12	48	.01651
13	35.5	.0162
14	5.5	.01512
15	38	.01498
16	60	.01466
17	36.5	.01431
18	120	.01332
19	52	.01066
20	50	7.000E-03

70.7-03 V/EA 1.00+00 E VLG

C

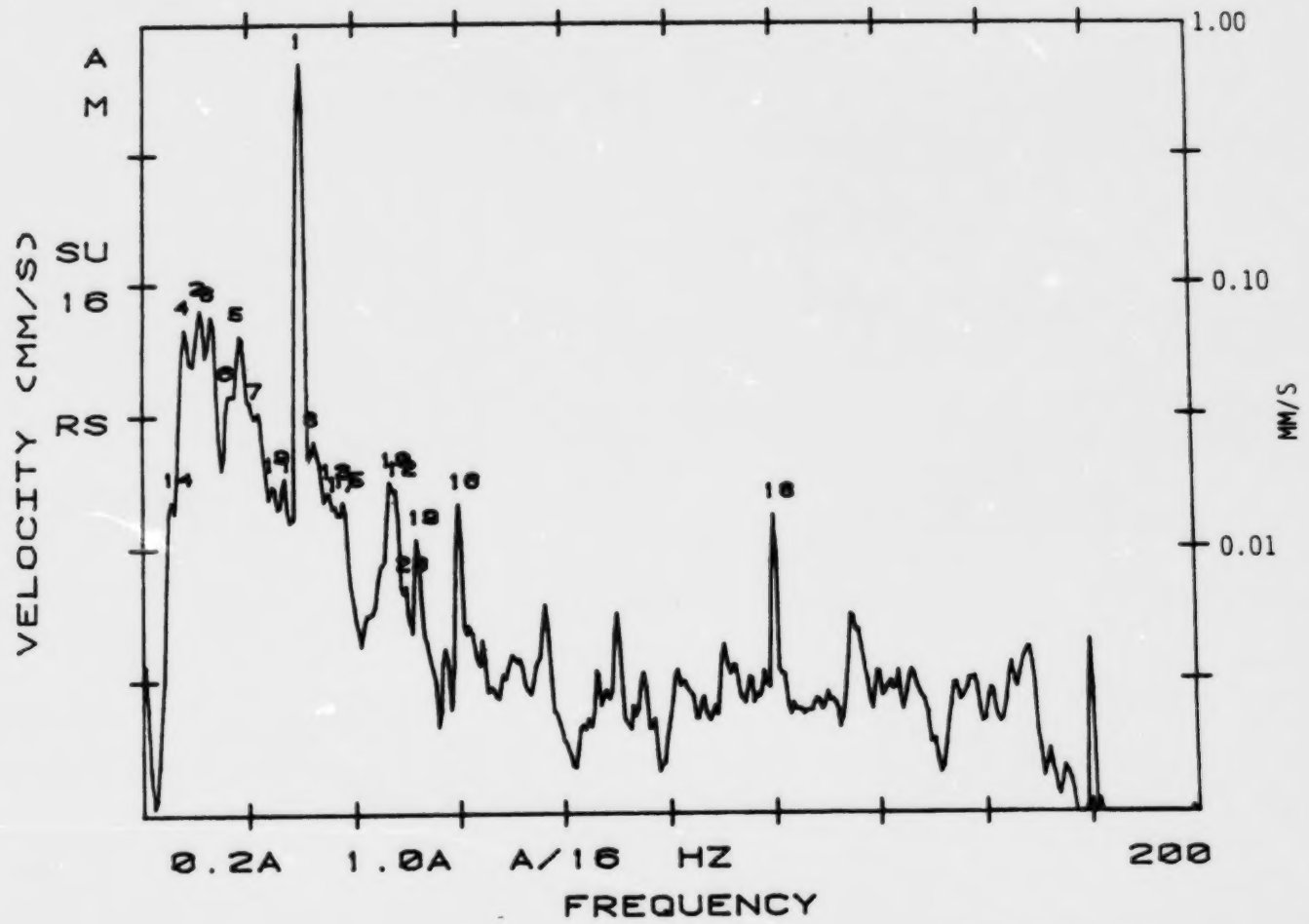


FIGURE 9

88-60

172326 1

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#21

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.3331
2	13.5	.1356
3	16	.07877
4	10	.06366
5	19	.05518
6	60	.04931
7	22	.02804
8	33	.02781
9	21	.02667
10	120	.02498
11	24.5	.02051
12	38	.01953
13	35.5	.01951
14	90	.0187
15	48	.01808
16	52	.01484
17	28.5	.01420
18	.5	.01198
19	45.5	.01173
20	5.5	8.169E-03

70.7-03 V/EA 1.00+00 E VLG

C

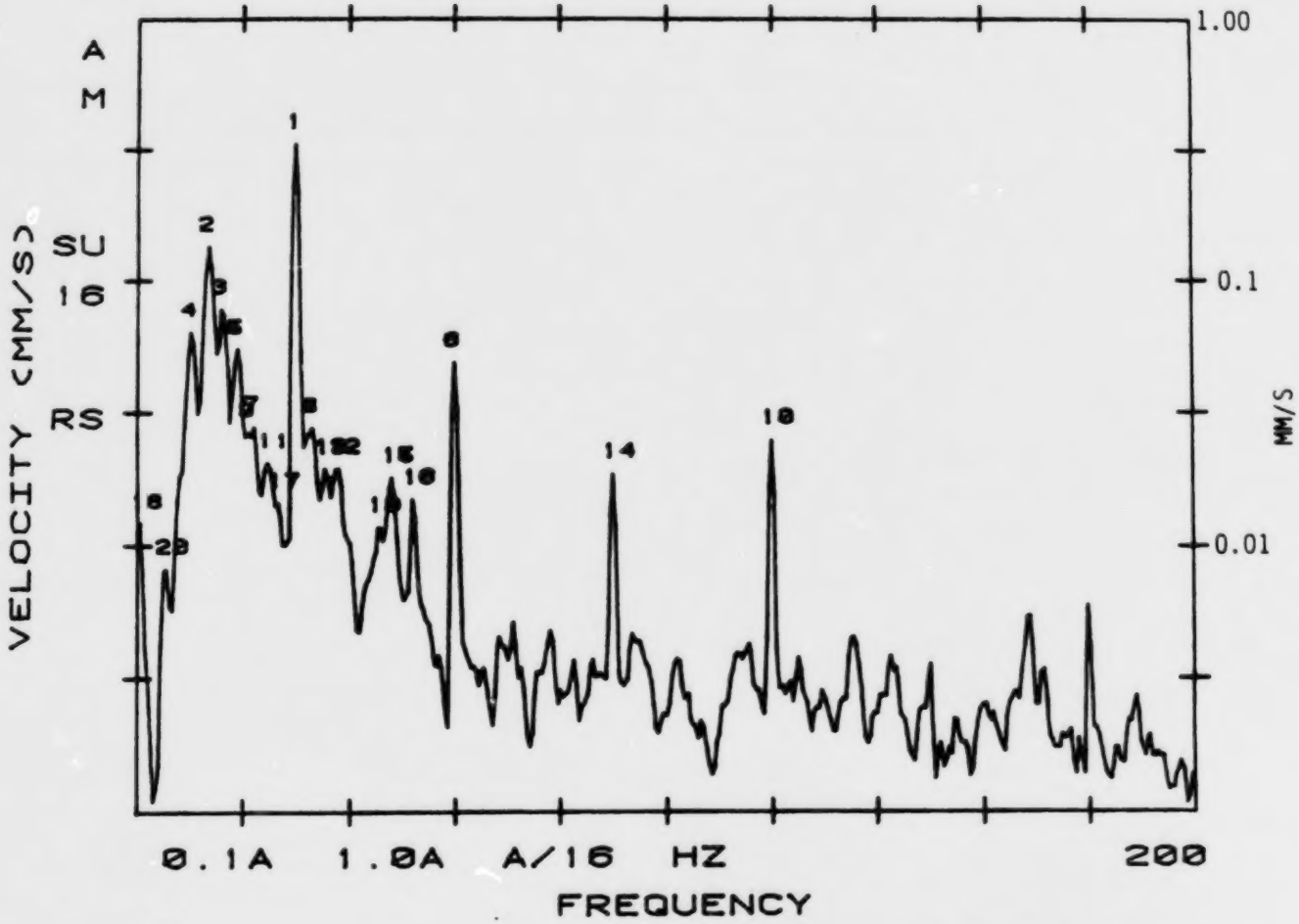


FIGURE 10

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#22

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.2593
2	18	.09105
3	13.5	.07213
4	10	.06132
5	19	.0333
6	22	.03013
7	32	.02703
8	120	.02442
9	24.5	.02148
10	34.5	.01774
11	36	.01573
12	47	.01573
13	37.5	.01558
14	60	.01333
15	27.5	.01081
16	52	7.583E-03
17	60.5	6.954E-03
18	90	5.815E-03
19	180	5.73E-03
20	61.5	5.254E-03

70.7-03 V/EA 1.00+00 E VLG

C

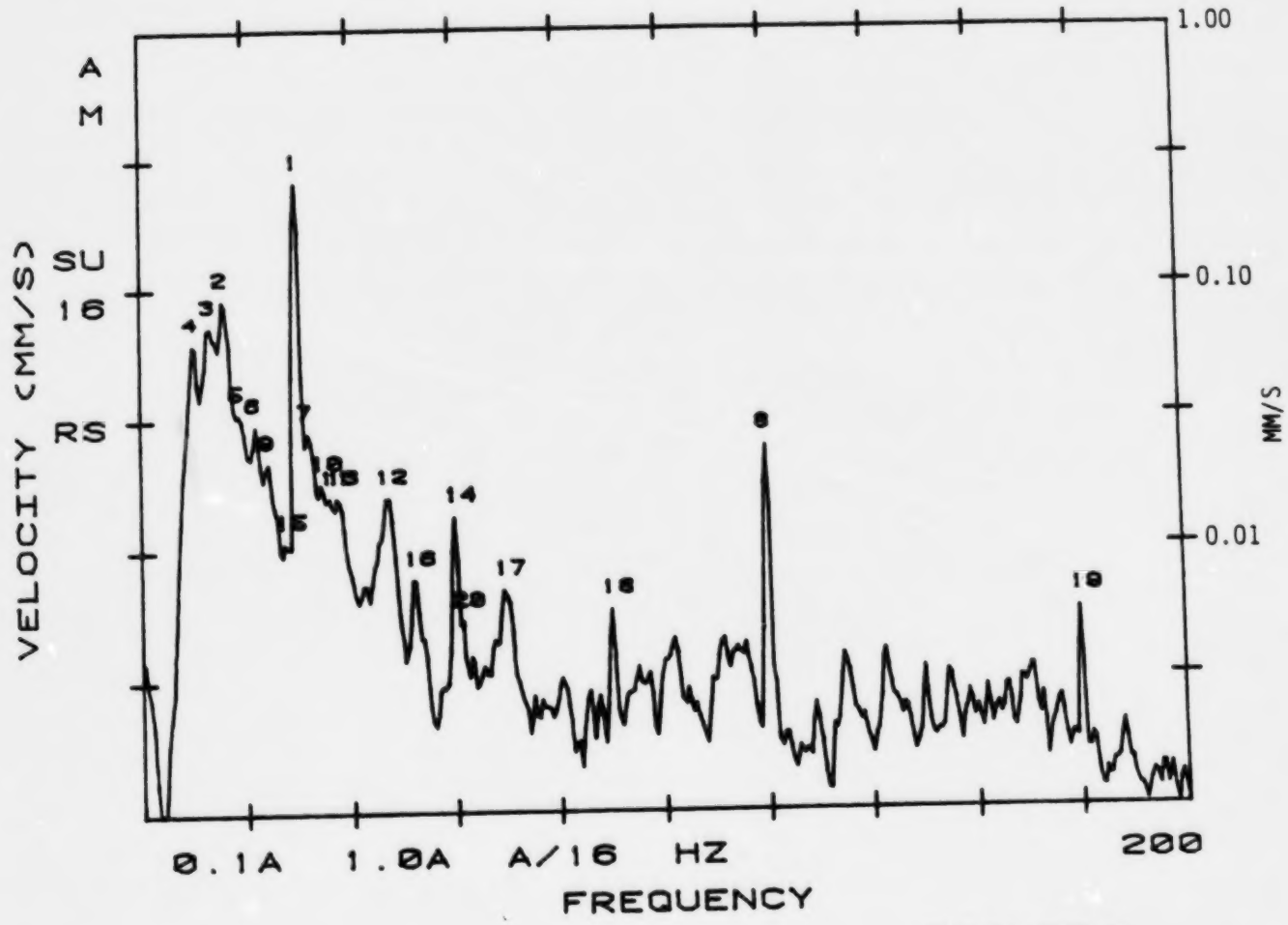


FIGURE 11

88-60

172328 E

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASURMENT LOCATION#23

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.0634
2	13.5	.00705
3	11	.00241
4	19.5	.04741
5	120	.04214
6	6	.03087
7	32	.02869
8	22	.02642
9	88	.02153
10	24.5	.01772
11	26	.01685
12	34	.01663
13	.5	.01423
14	48.5	.0141
15	68	.01321
16	46	7.802E-03
17	36	7.670E-03
18	70	7.563E-03
19	44.5	7.341E-03
20	47.5	6.731E-03

70.7-03 V/EA 3.16+00 E VLG

C

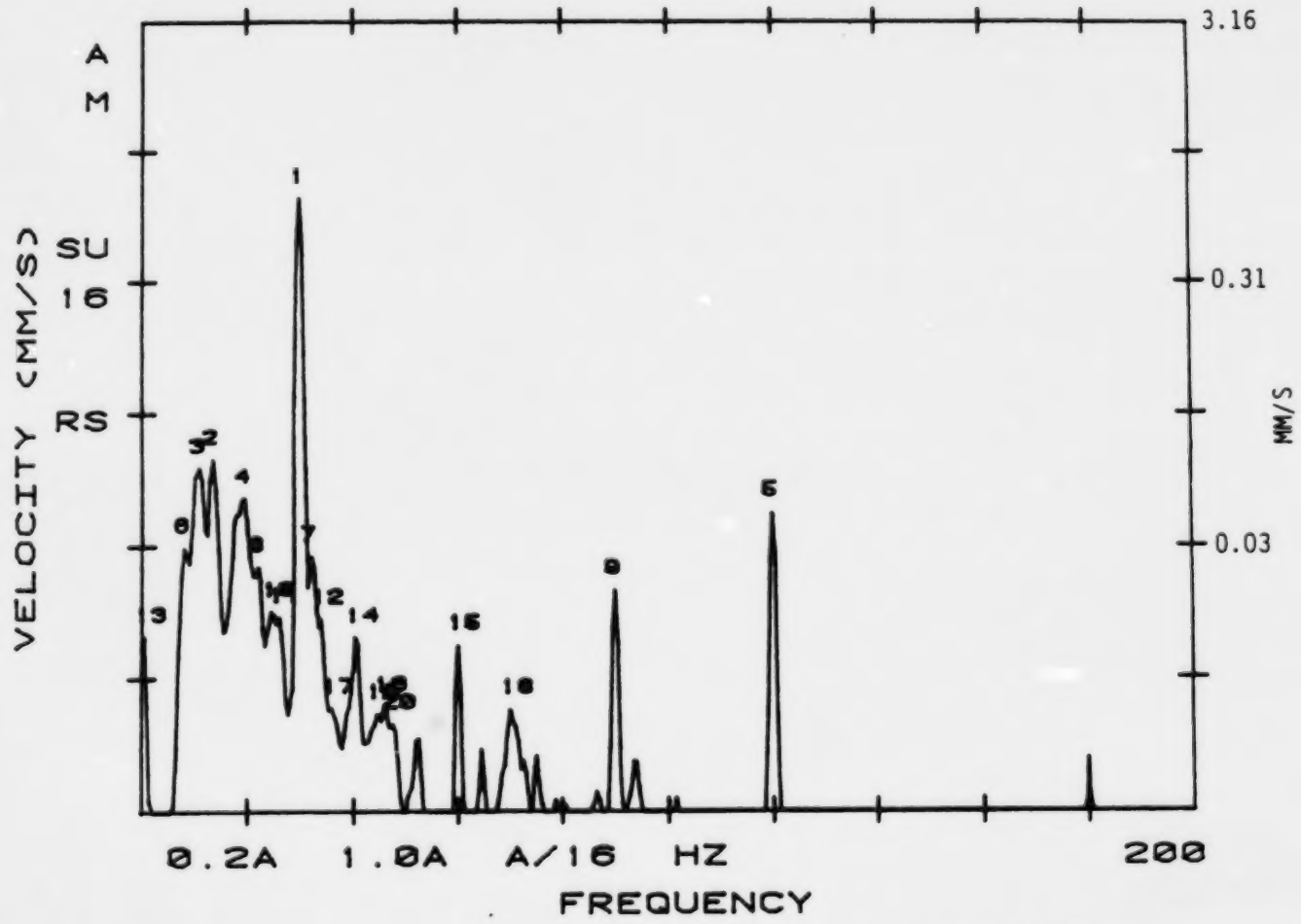


FIGURE 12
88-60

BRUCE NGSB UNIT#7
TURBO-GENERATOR FOUNDATION
MEASUREMENT LOCATION#24

PEAK NO.	FREQUENCY	AMPLITUDE
1	30	.7954
2	13.5	.1548
3	10.5	.1466
4	17	.07361
5	120	.04978
6	22.5	.04295
7	20.5	.03454
8	32.5	.03133
9	36	.02858
10	25.5	.02797
11	60	.01433
12	48.5	.01248
13	45.5	.01173
14	41	.01103
15	180	7.728E-03
16	90	7.100E-03
17	64.5	6.814E-03
18	52.5	6.402E-03
19	75	6.206E-03
20	57	5.577E-03

70.7-03 V/EA 1.00+00 E VLG

C

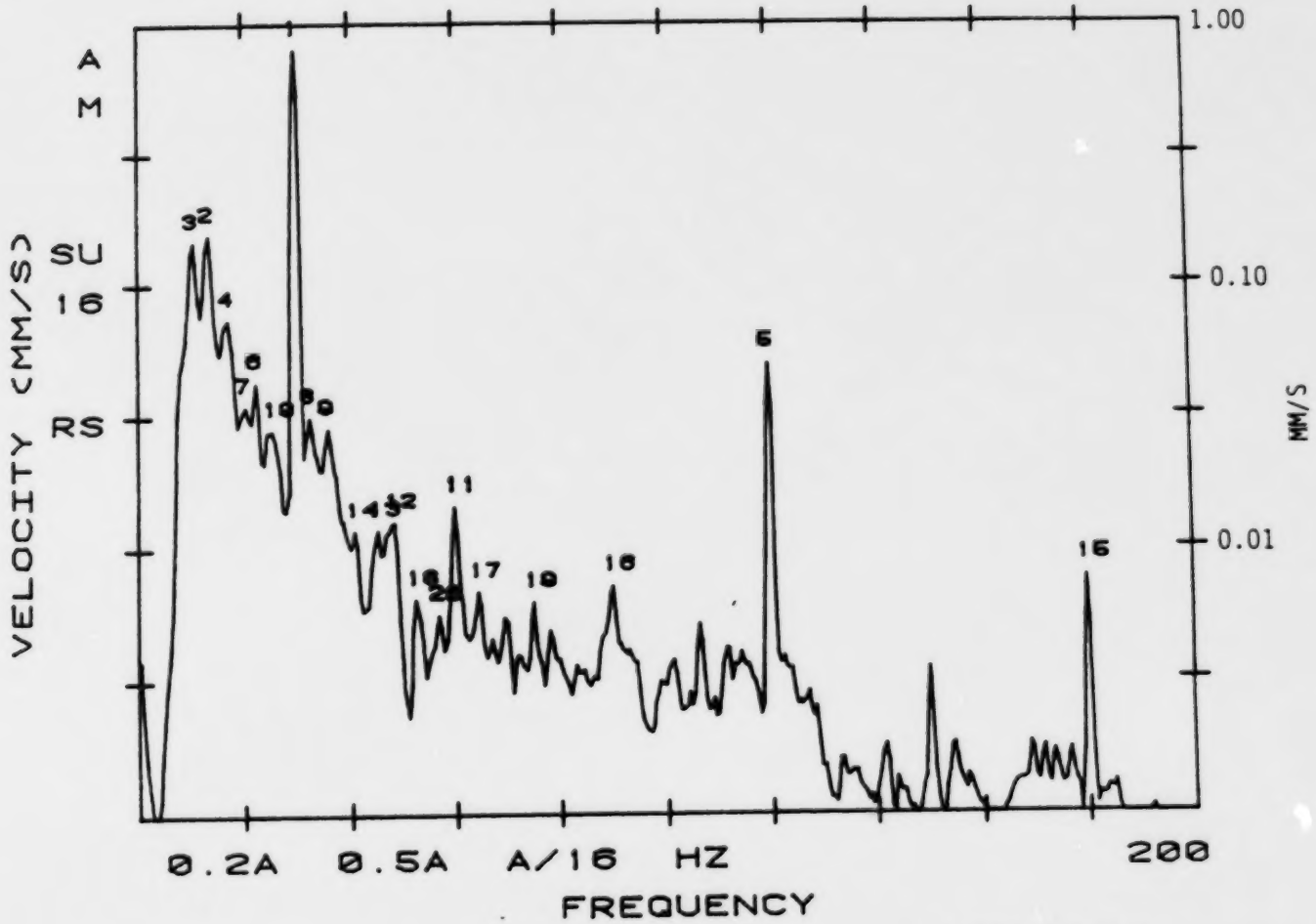
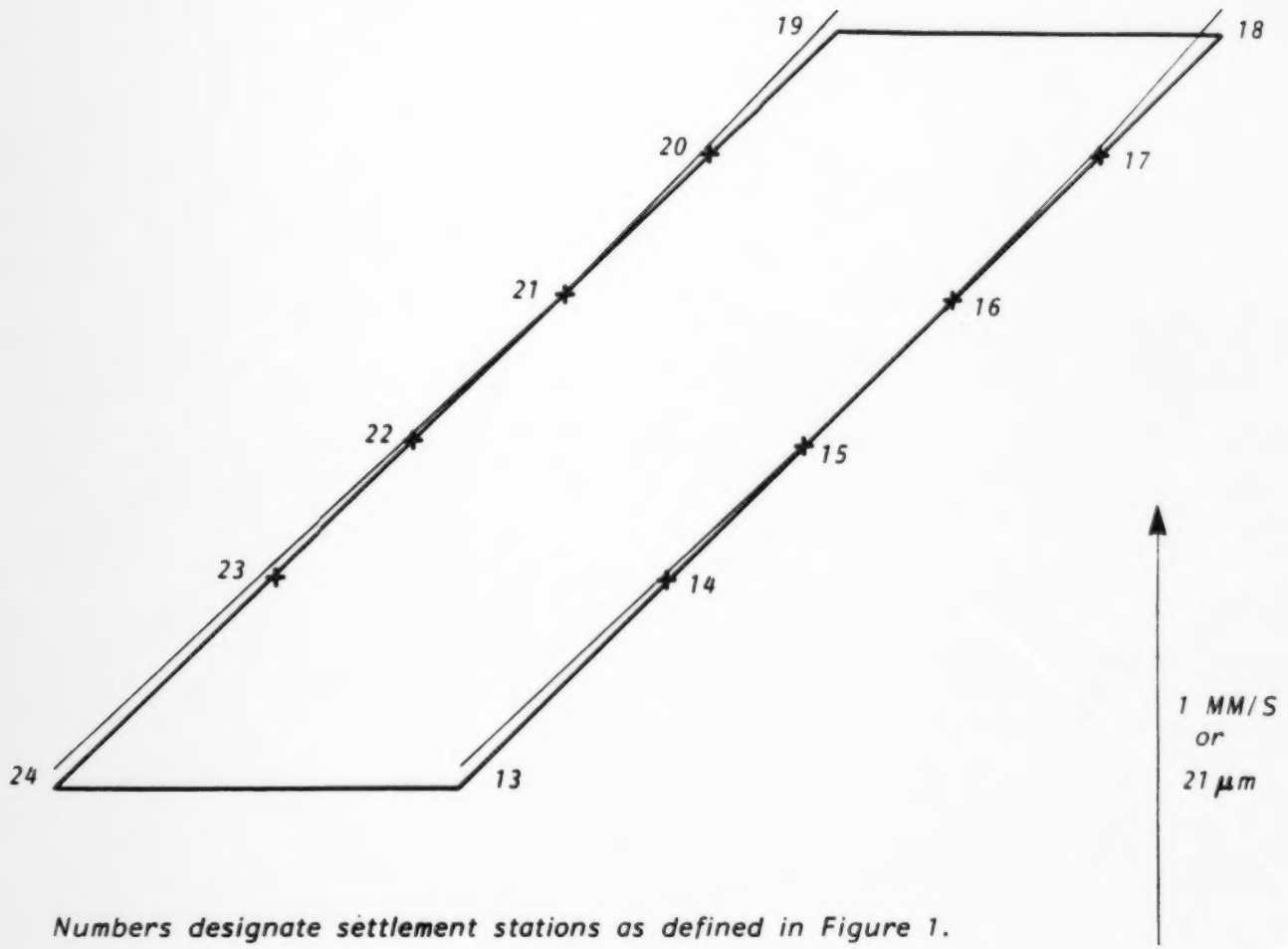


FIGURE 13

88-60

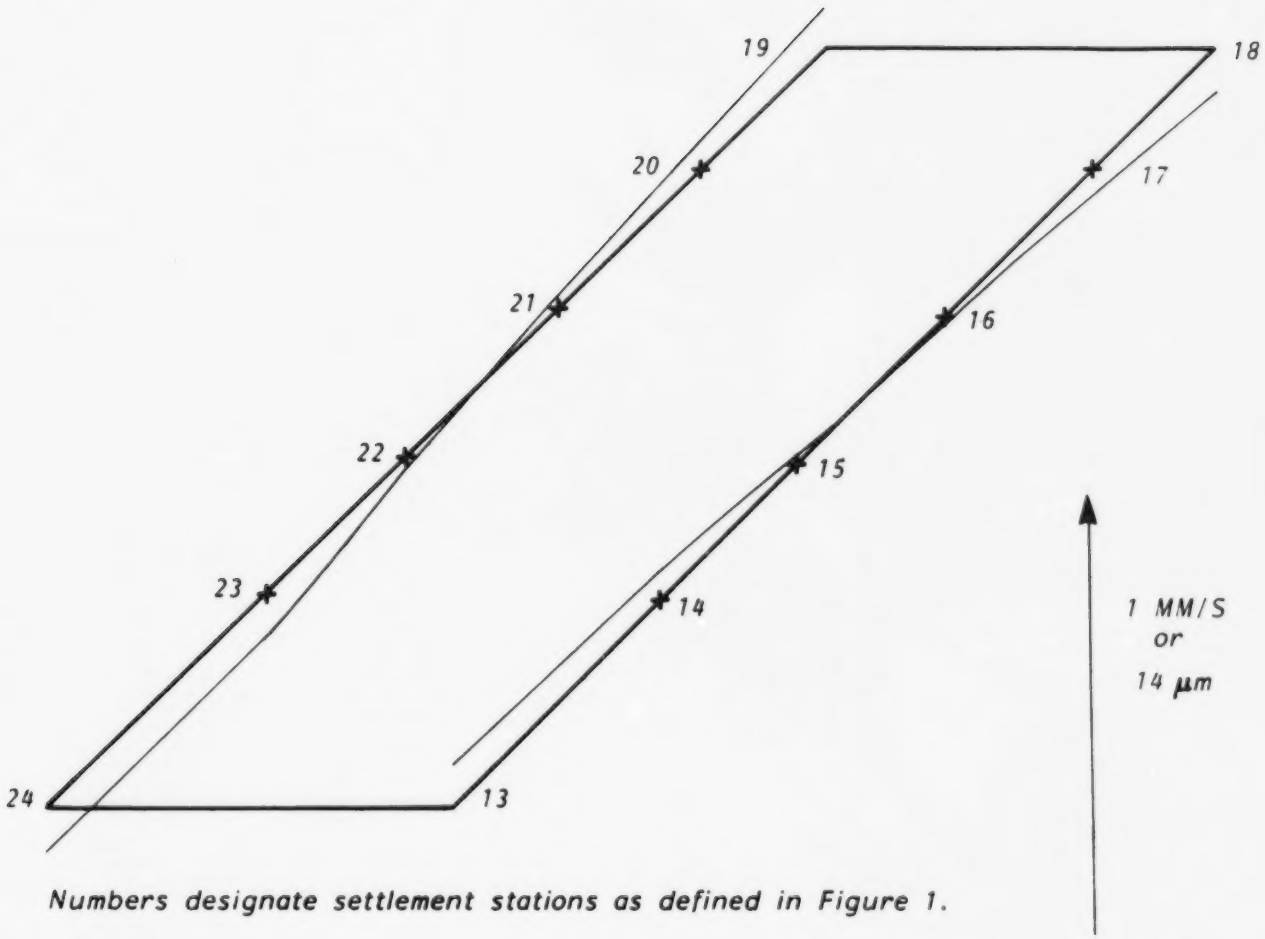
172330 R[



Numbers designate settlement stations as defined in Figure 1.

FIGURE 14

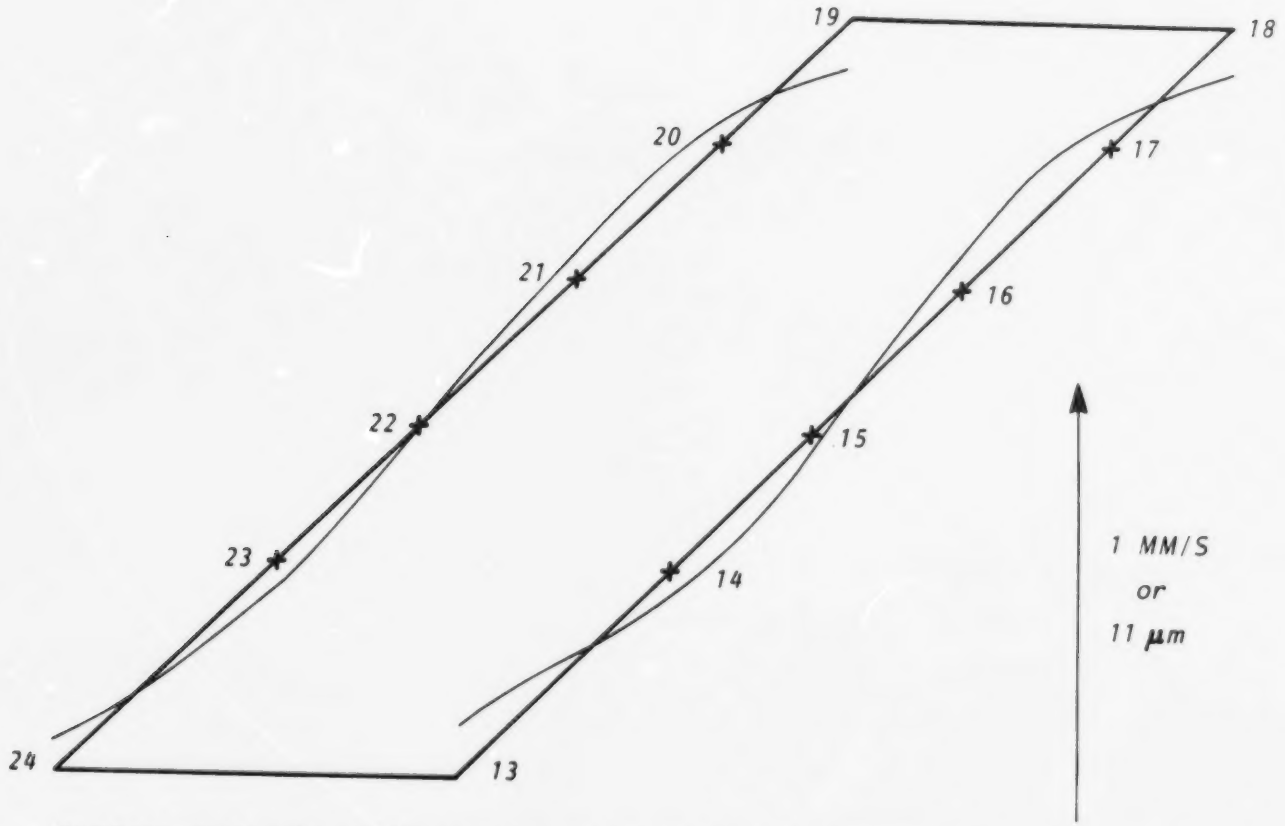
BRUCE NGS B - UNIT 7
TURBO-GENERATOR FOUNDATION
VERTICAL DISPLACEMENTS & VELOCITIES AT 8 Hz



Numbers designate settlement stations as defined in Figure 1.

FIGURE 15

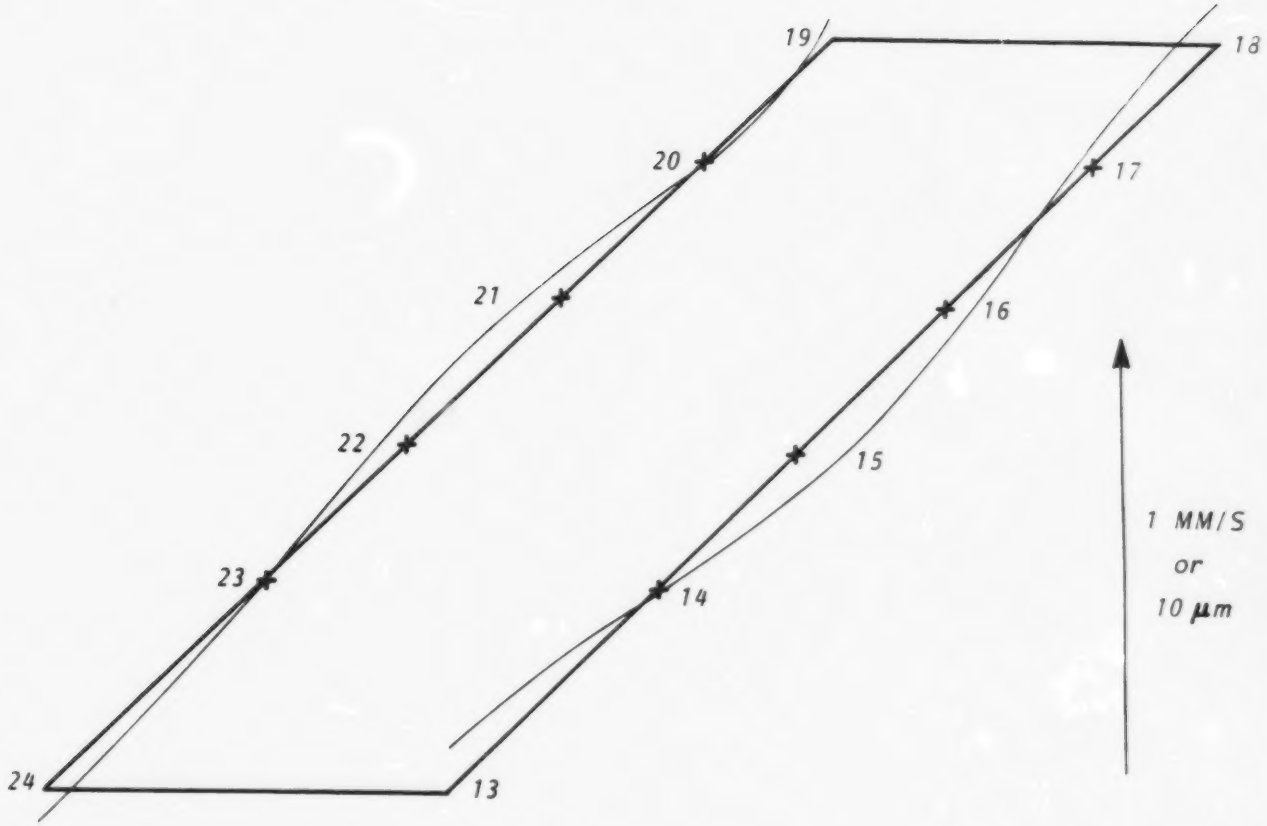
BRUCE NGS B - UNIT 7
TURBO-GENERATOR FOUNDATION
VERTICAL DISPLACEMENTS & VELOCITIES AT 11 Hz



Numbers designate settlement stations as defined in Figure 1.

FIGURE 16

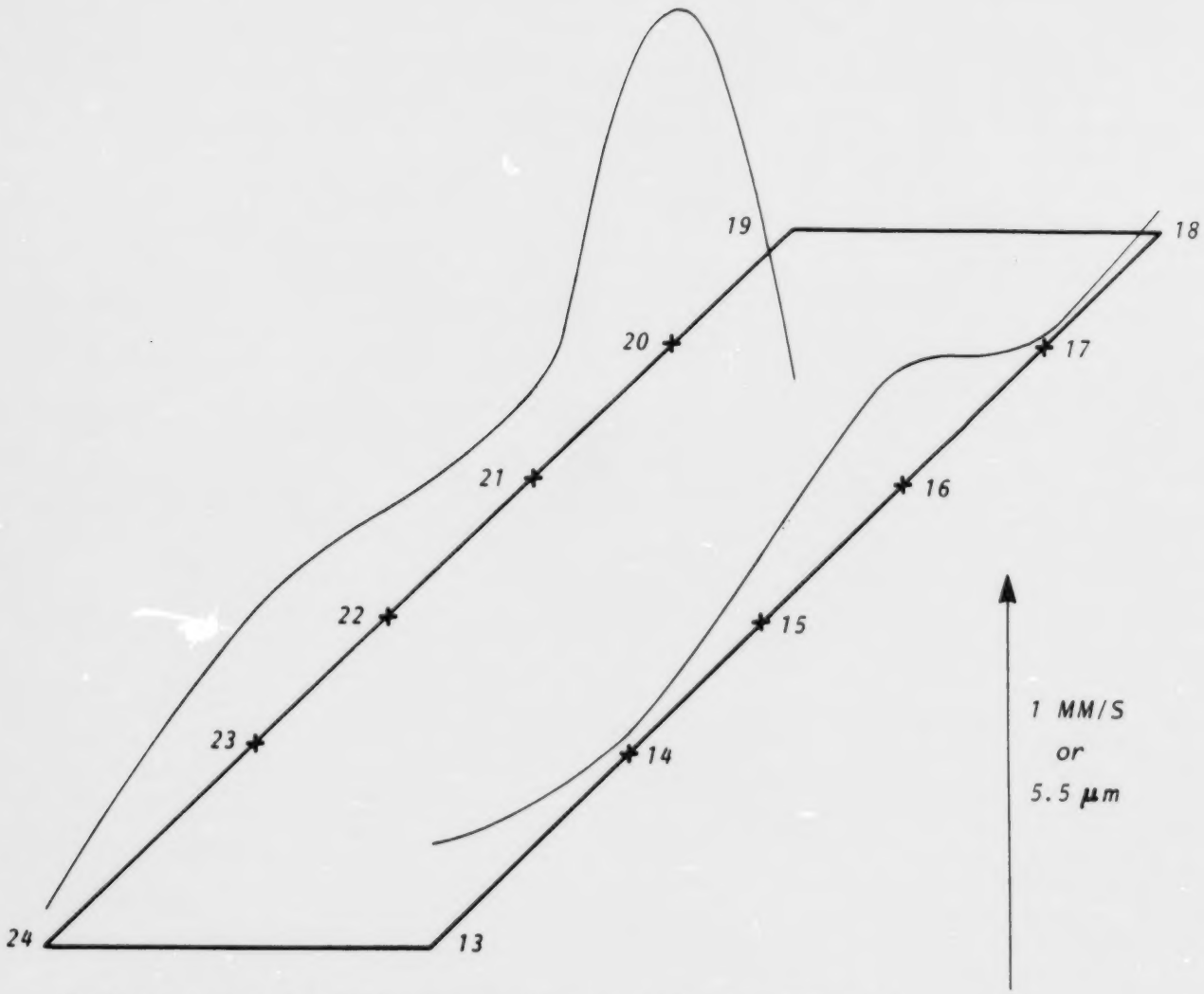
BRUCE NGS B - UNIT 7
TURBO-GENERATOR FOUNDATION
VERTICAL DISPLACEMENTS & VELOCITIES AT 13.5 Hz



Numbers designate settlement stations defined in Figure 1.

FIGURE 17

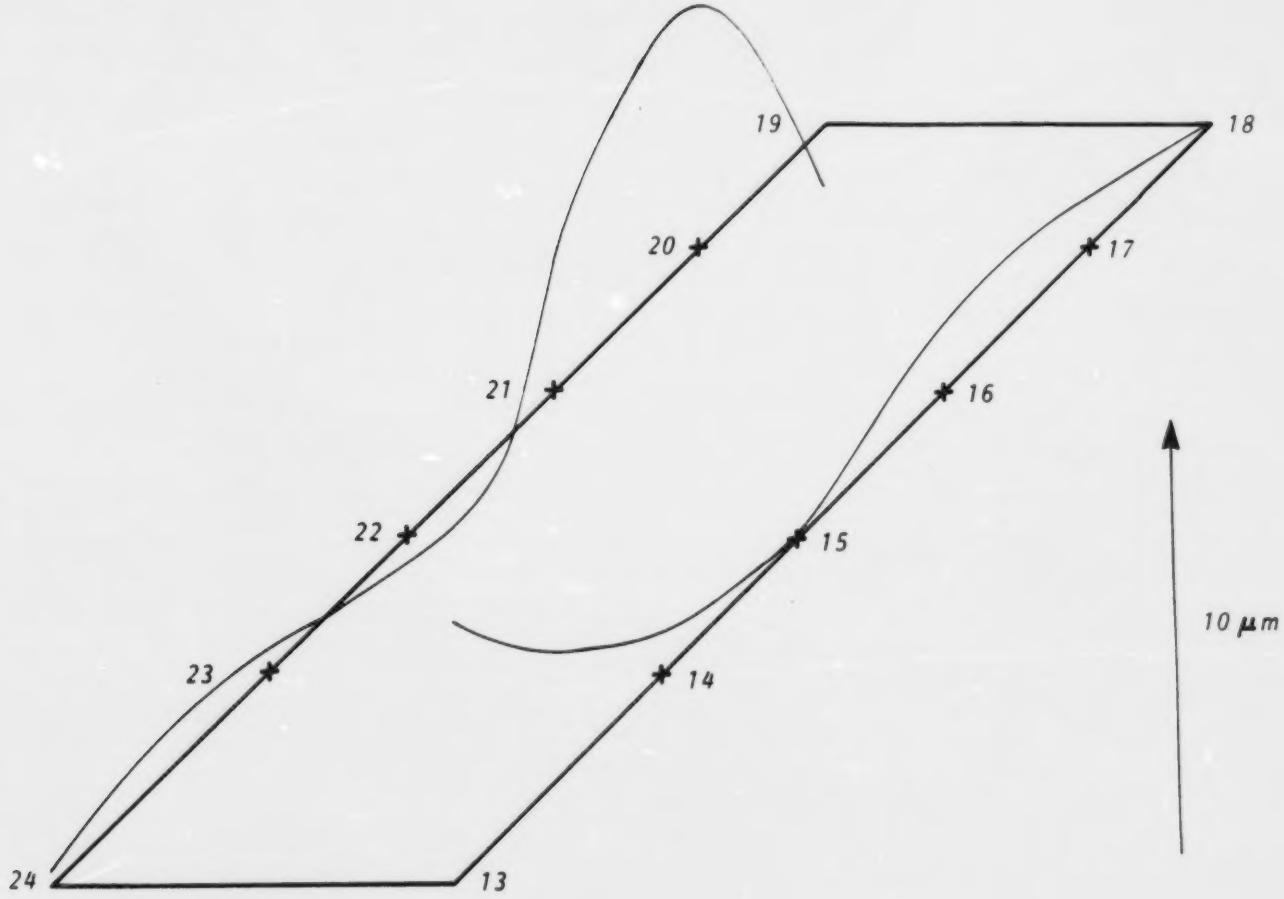
BRUCE NGS B - UNIT 7
TURBO-GENERATOR FOUNDATION
VERTICAL DISPLACEMENTS & VELOCITIES AT 16.5 Hz



Numbers designate settlement stations as defined in Figure 1.

FIGURE 18

BRUCE NGS B - UNIT 7
TURBO-GENERATOR FOUNDATION
VERTICAL DISPLACEMENTS & VELOCITIES AT 30 Hz



Numbers designate settlement stations defined in Figure 1.

FIGURE 19

BRUCE NGS - UNIT 7
TURBO-GENERATOR FOUNDATION MODE SHAPE
(CONSTRUCTED FROM MEASUREMENTS AT 8,11,13.5,16.5 & 30 Hz)

86-06-24
172336 RD

APPENDIX A

INSTRUMENTATION

1. B&K accelerometers, model 4370 and charge amplifiers type 2365

   SN 675724
   SN 675398

2. Bently Nevada Digital Vector Filter, Model DVF 2

3. Nicolet 660B dual channel FFT analyzer and plotter

4. Hewlett Packard 3968A Instrumentation Recorder

5. Apple Computer